DANIEL ON THE MOON

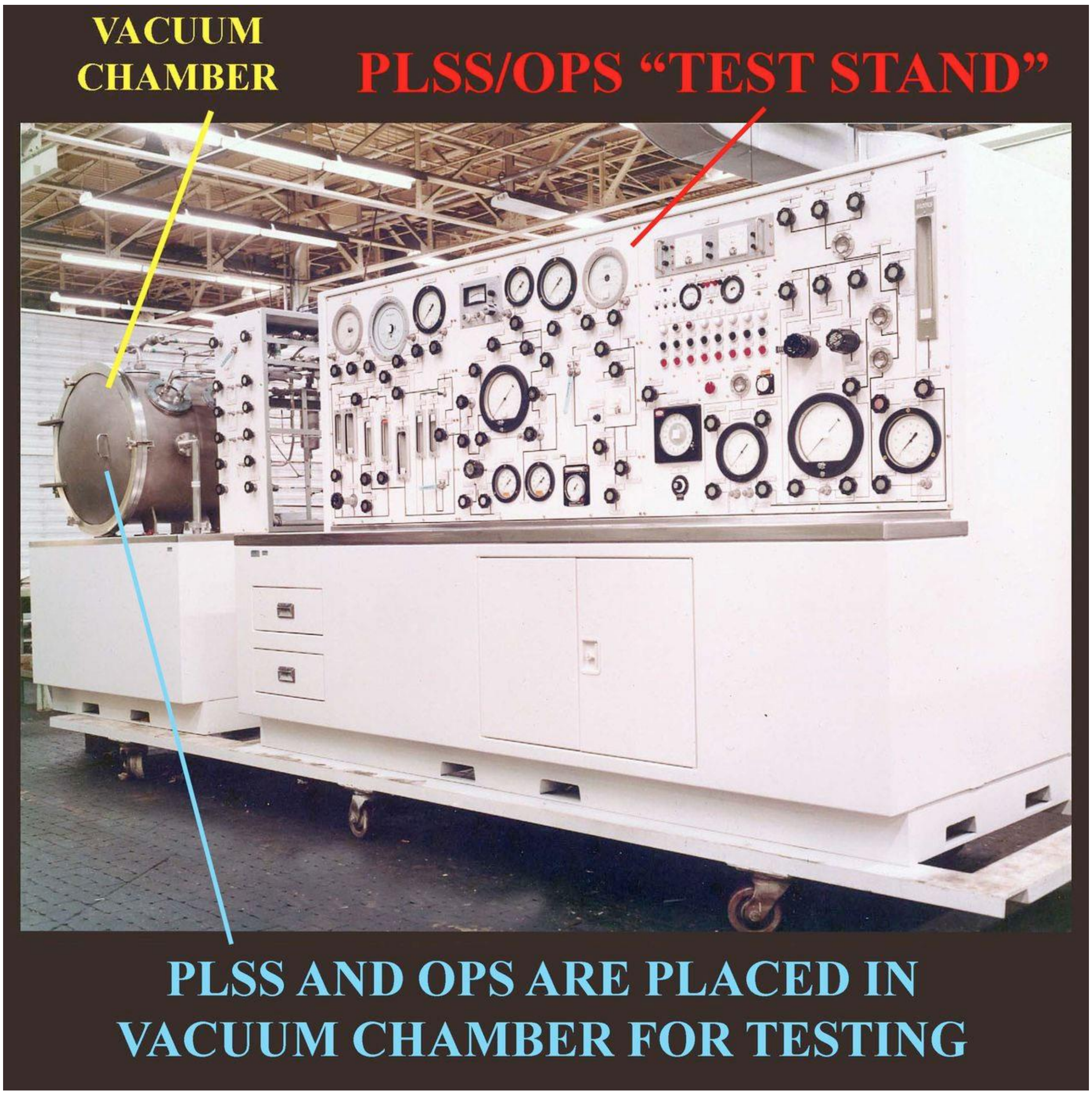
TECHNICAL ASPECTS PART 2

TESTING FLIGHT HARDWARE BEFORE MISSIONS

As Apollo 11 LM-5 PLSS/OPS Mission Manager, I was responsible for conducting the PLSS (Portable Life Support System) "Pre-Installation Acceptance" (PIA) testing for both Armstrong's and Aldrin's PLSS. I was excited when I found the PLSS S/N015 (Armstrong's Flight PLSS) report I wrote summarizing the actual testing of Armstrong's PLSS.

The testing began on June 23, 1969 and was completed on July 10, 1969, just six days before Apollo 11 liftoff (July 16, 1969).

The procedures that all contractors had to follow with respect to conducting tests were as follows: First, a "Test Preparation Sheet" (TPS) was written to authorize the testing. Then, a "Test and Checkout Procedure" (TCP) was written to include the specific procedures used to conduct the test, i.e. how a specific components function was to be evaluated using the Test Facility that was used to simulate the environment that the component was designed for. All of the PLSS System, Sub-system, and Component testing was performed using our HSD Test Facility and as we called it, the "PLSS/OPS Test Stand". The Test Stand included the Vacuum Chamber that simulated the vacuum of space. Below is a photo of the PLSS/OPS Test Stand:



As the contractor engineer in charge of the test, I read each line of each procedure to the HSD technician who turned the dials, pushed the switches, read the gauges, etc. After each test procedure, if the PLSS subsystem, component, etc. performed within test specifications, both the HSD Quality Control inspector and a NASA Quality Control inspector placed an approval stamp next to the procedure in the TCP.

If, during the execution of testing, there was an undiagnosed issue, an "Interim Discrepancy Report" (IDR) was written and logged in a "Test And Inspection Record" (TAIR) Book without stopping the test. Following the completion of the test, the IDR would be further investigated and dispositioned as either resolved or up-graded to a "Discrepancy Report" (DR).

A DR was written by the contractor QC inspector for any out of specification test result. The DRs were entered into the TAIR book. DRs remained open until they were dispositioned and signed by the test engineer (me) and a NASA contractor engineer liaison that was permanently assigned to the contractor.

With the above testing procedures including resulting IDRs and DRs, I present to you (below) the final page of PLSS S/N015 Summary Report for Neil Armstrong's PLSS written on July 11, 1969, a day after test completion. An obvious question you might ask is why is my report handwritten? The reason my report was not typed was, believe it or not, because our company secretary was home sick. Remember, back in those days we had no desk computers and no word processing. There were, in fact, many internal documents that were approved hand written.

Finding this report brought back incredible memories of how I felt conducting the 18 day test and how lucky I was to be in the "right place at the right time." Just five days after the conclusion of Armstrong's PLSS flight approval testing and T-28 hours, I was stowing the Apollo 11 PLSSs and OPSs in the Lunar Module on Pad 39. I just pinched myself as I probably did back then!!

“THE PRE-FLIGHT CHECKOUT TCP-EVA-K-1005 IS COMPLETE AND ALL SYSTEMS ARE ACCEPTABLE FOR FLIGHT.

DANIEL O. SCHAIEWITZ 7/10/69

SUMMARY SHEET

SUBJECT:

SYNOPSIS: excursion. Deviation # 27 was written to verify normal operating condition of the PLSS T/S after performing a test out of sequence. One(1) deviation was written to purge out a test stand line that was inadvertantly wet. Deviation # 36 was written to remove PLSS S/N 015 from the test stand such that a test could be performed on another PLSS. The Pre-Flight checkout PIA TCP-EVA-K-1005 is complete and all systems are acceptable for flight.

Daniel O. Schaiewitz 7/10/69

STAFFING

ORGANIZATION	ACTION	ORGANIZATION	ACTION

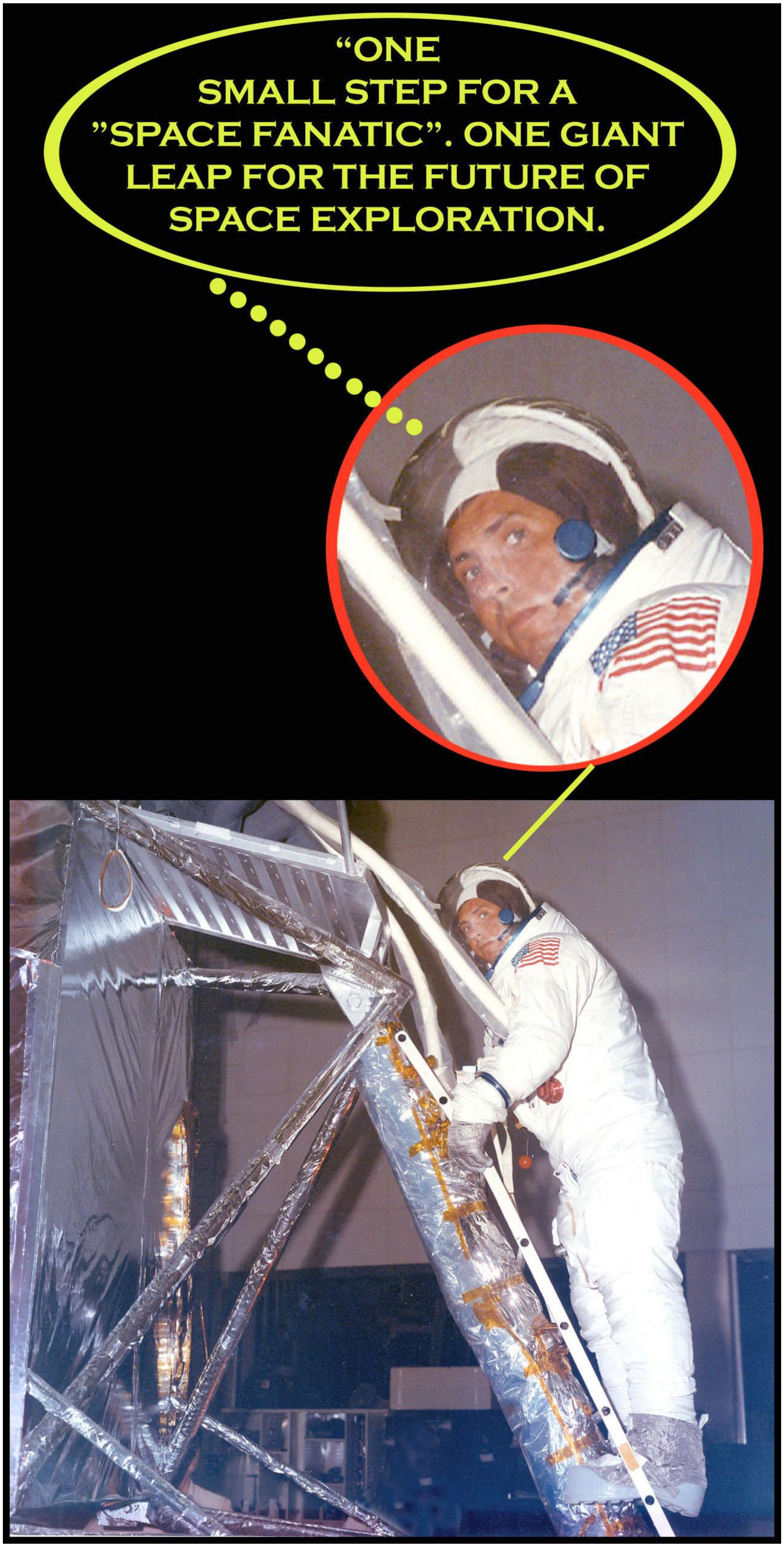
5

REMARKS:

KSC FORM 11-103 NS (3/66)

CLIMBING AND DESCENDING THE LUNAR MODULE LADDER

I wonder what it feels like to take that "first step"! I think I'll borrow Neil's suit and find out for myself! That's "One Small Step For A Space Fanatic and One Giant Leap For the Future Of Space Exploration"! Let me explain: The first photo below is myself monitoring a procedure involving Astronaut Armstrong simulating his first step onto the lunar surface in the Crew Training Building at the Kennedy Space Center (KSC). The next photo is me in Armstrong's training suit simulating the same walk down the same LM ladder in the Crew Training Building!


"ONE
SMALL STEP FOR A
"SPACE FANATIC". ONE GIANT
LEAP FOR THE FUTURE OF
SPACE EXPLORATION.

DESIGNING A LM INTERIOR MOCKUP FOR LM PRE AND POST PROCEDURE EVALUATIONS

Very little information has been disseminated about Apollo EVA crew training at KSC. Most disseminated information including photos, involve EVA training related to astronauts and "flight hardware," i.e. flight PLSS/OPS's and flight suits.

As PLSS/OPS Crew Training Mission Manager, I was responsible for coordinating the PLSS/OPS crew training effort at KSC.

I feel that I have a responsibility to document the "behind the scenes" effort required to assure that EVA crew training schedules and milestones were met for future historians.

Okay, let's begin with a story related to EVA prep and post procedural demonstrations in the KSC Crew Training Building:

When Apollo EVA crew training was assigned to KSC, MSC Houston sent a memo to KSC with a requirement to build a mockup of the LM PLSS/OPS/PGA donning and doffing "space" (inside the LM) to be used when EVA Prep and Post demonstrations needed to be monitored by multiple NASA and contractor personnel. There was no logistical solution for multiple personnel to monitor prep and post procedural demonstrations inside the crew training building LM mockup and therefore the need for the requested LM EVA prep and post "platform" (as I named it), i.e. a platform that included the LM Ascent Engine Cover, the Cabin Recirculation Assembly and their respective vertical positioning inside the LM.

Photo #1 below depicts the LM interior including the LM ascent Engine Cover, the Cabin Recirculation Assembly and the "restrictive" area inside the LM where the prep and post "donning" and "doffing" were conducted. We used Grumman drawings and also measured actual dimensions as a dimensional "double check." I was and still am a perfectionist and the double check paid off as there was a dimensional error on the drawing that if used without confirmation would have resulted in a flawed "platform."

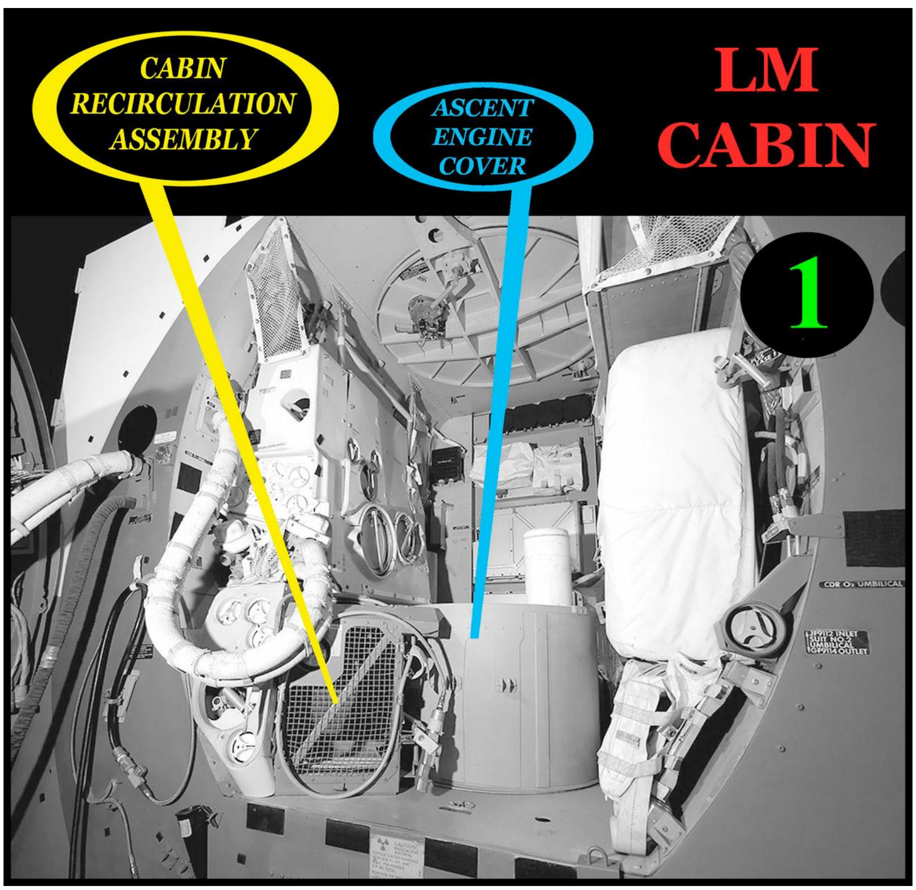


Photo #2 shows the finished mockup platform. The one regret I have is that we should have vertically extended the sides to more accurately represent the restrictive environment when the astronauts were using their arms.

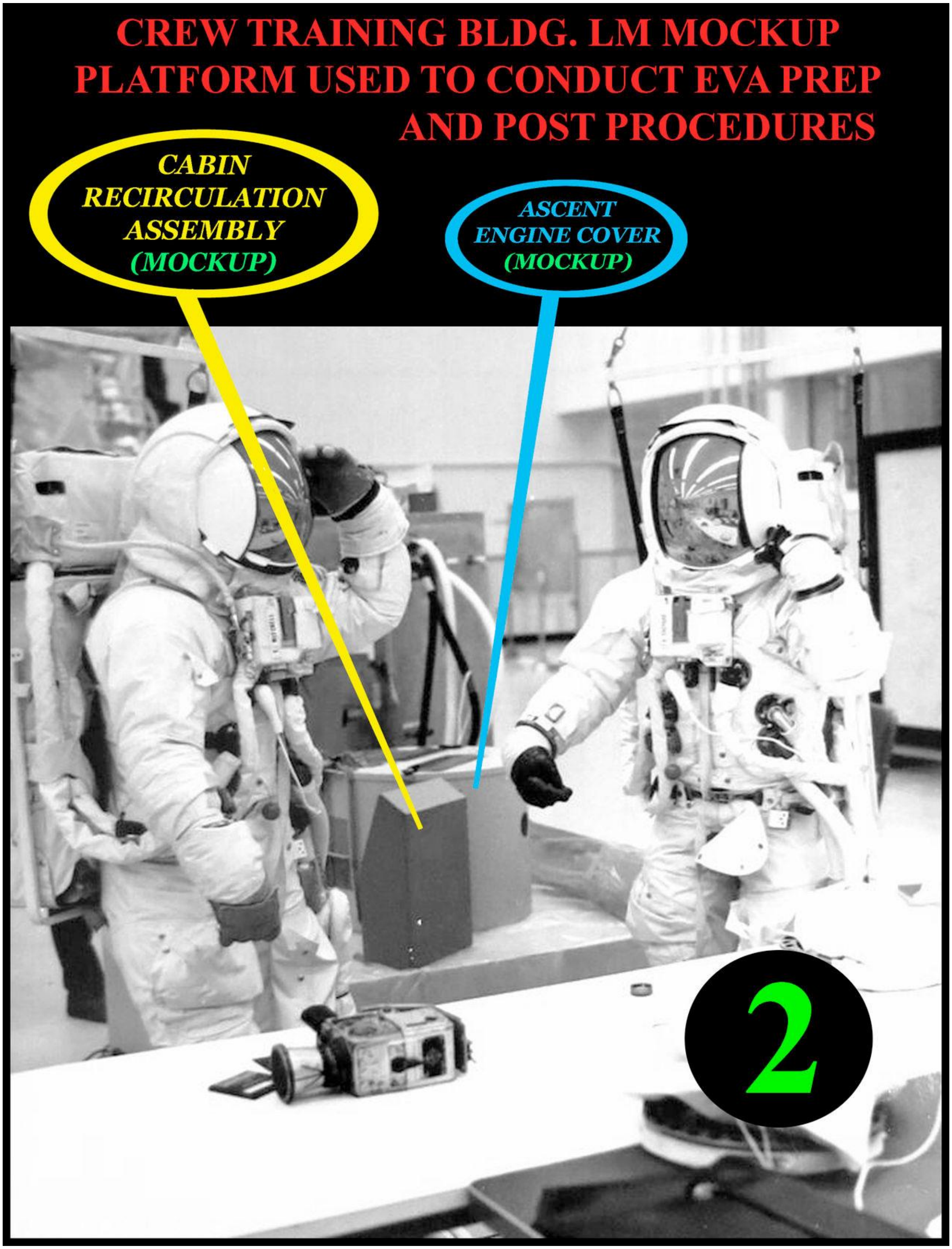


Photo #3 shows Apollo 15 Astronauts Scott and Irwin going through a prep and post procedure with multiple NASA and contractor personnel in attendance. You can see me in Photo #3 with a copy of the procedures. My job was to document crew questions and document requested crew procedural changes and possible hardware modifications for evaluation after the exercise was completed.

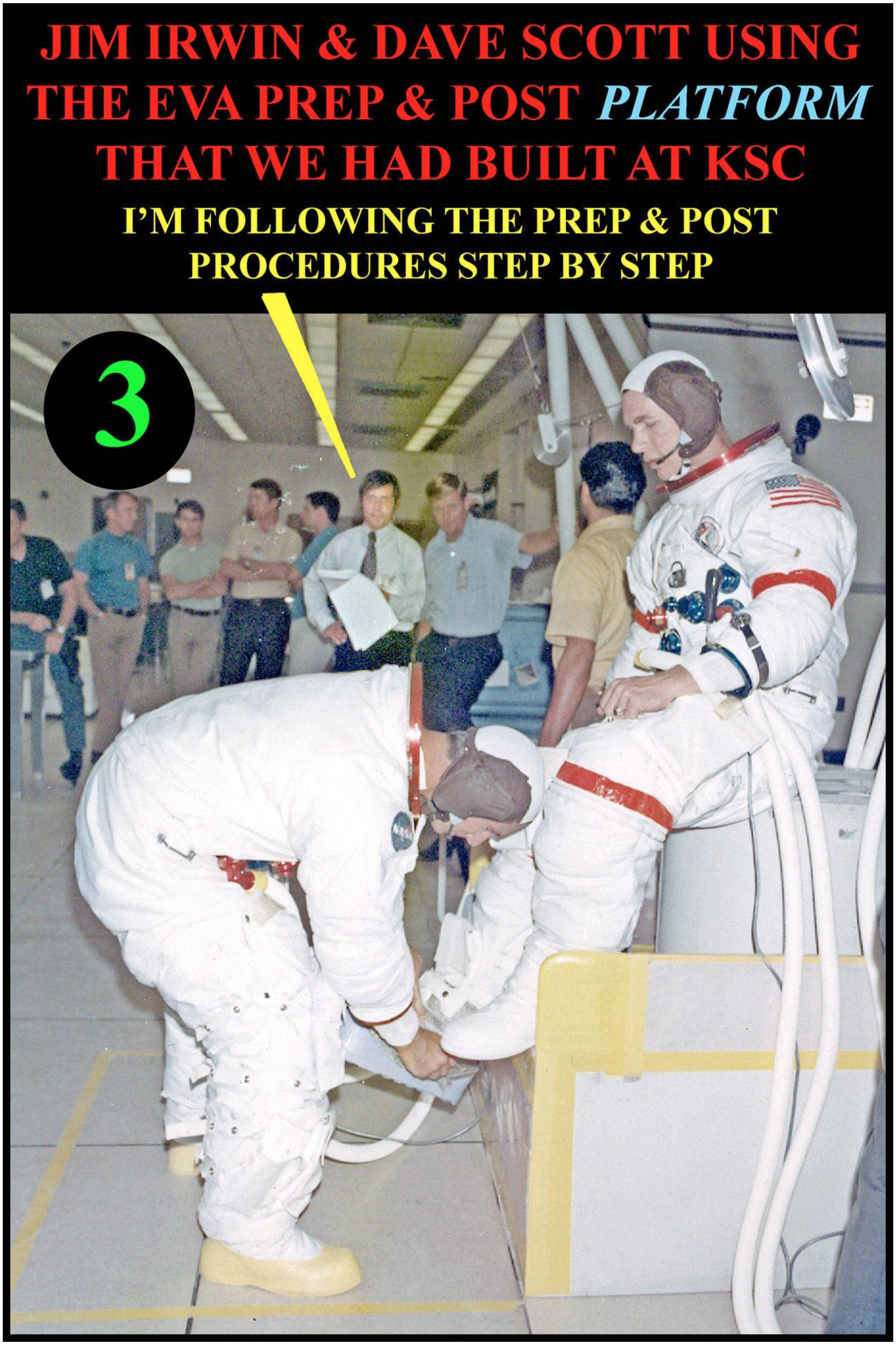
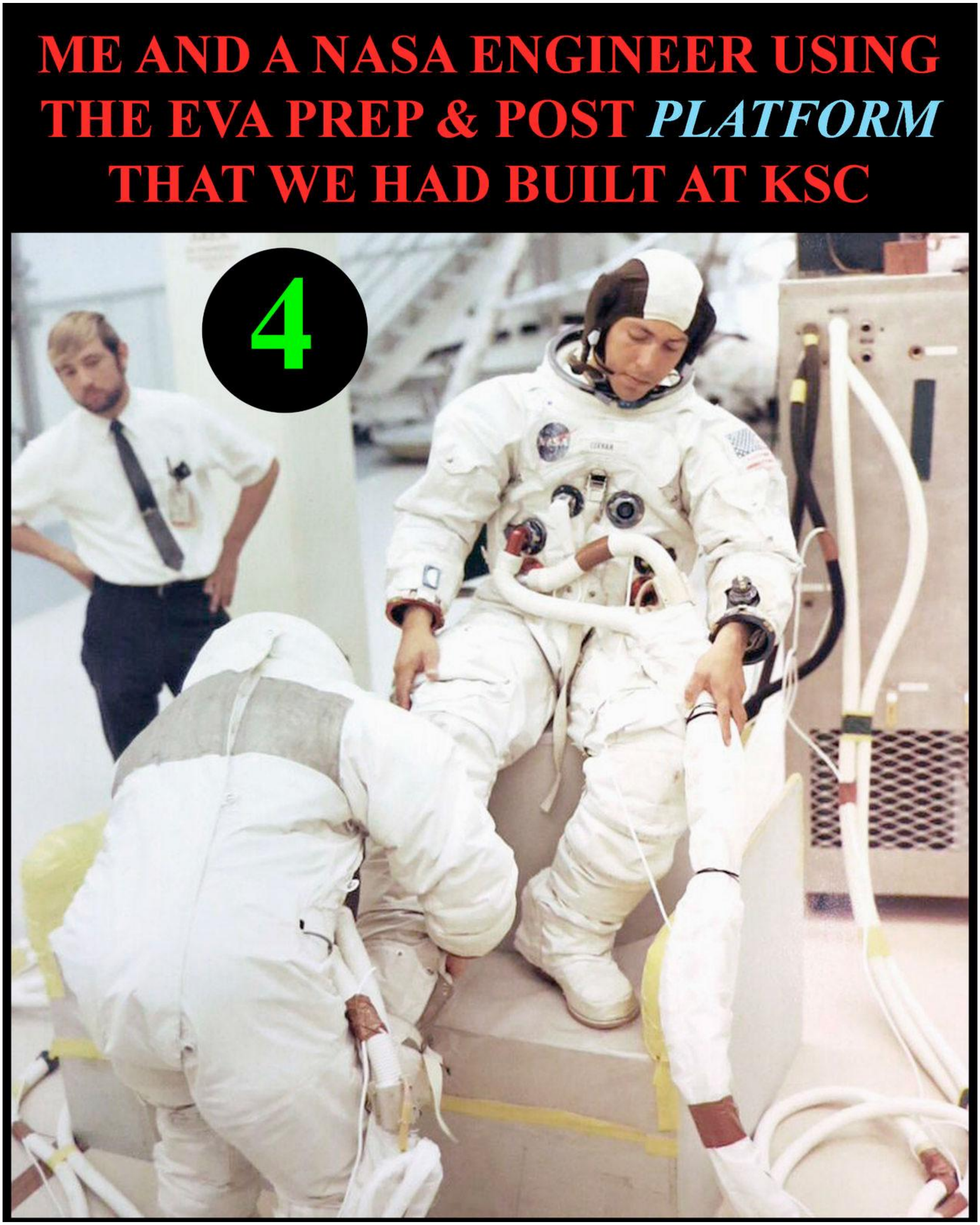


Photo #4 shows myself and a NASA Suit Engineer going through the same prep and post procedures that the astronauts had previously completed on, of course, the "platform". Our objective (myself and my fellow "wannabe" astronaut) was to evaluate incorporated approved procedural and/or hardware modifications for validation. If validated, they would be permanently incorporated into the applicable NASA document.



PROBLEMS WITH THE OPS COMMUNICATIONS ANTENNA AND SUSEQUENT RESOLUTION

As I document my Apollo related experiences, I want you to know that I am as passionate now about my experience(s) during my employment at KSC as I was then. The only difference is that I was a 24 year old given the opportunity to live a dream then and I'm now a 75 year old reliving the dream through vivid memories and loving it!

One of those memories I'm hoping should be of interest to readers that can't get enough of "behind the scenes" detailed technical stories about problems and their solutions is as follows:

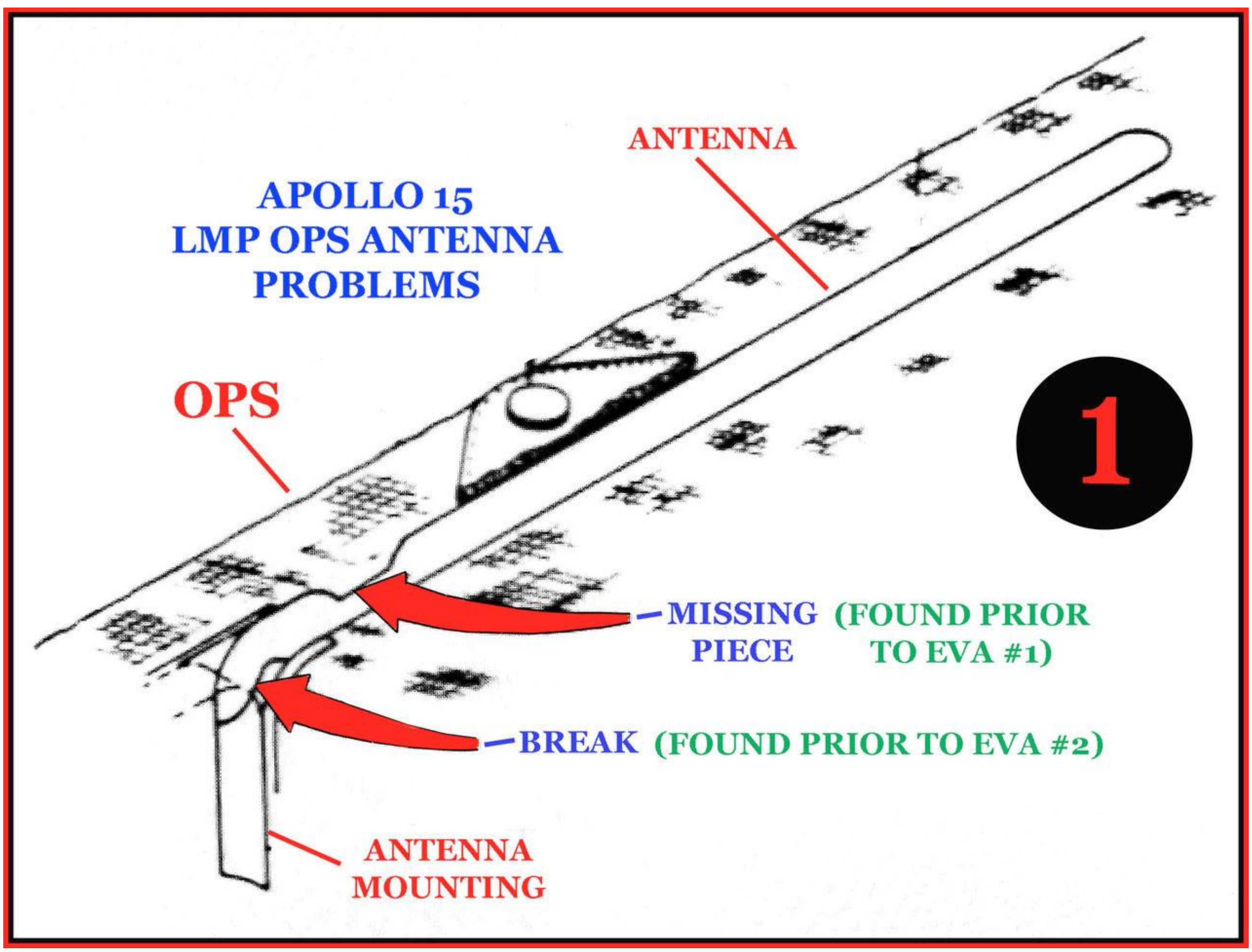
During both Apollo 15 and Apollo 16 EVAs, problems with Oxygen Purge System (OPS) antennas being broken, nicked and/or both were documented.

Apollo 15 OPS Antenna Problems

Prior to Apollo 15 EVA #1, LMP Jim Irwin noticed a significant "nick" in his OPS antenna about half the width of the antenna (Figure 1 below). Apollo 15 CDR Dave Scott and Irwin wrapped a piece of tape around the nicked portion of the antenna and pressed on with EVA #1 without any mention of the incident to Houston. They apparently feared that a discussion about the problem and a possible solution would either delay the EVA or possibly even cancel it.

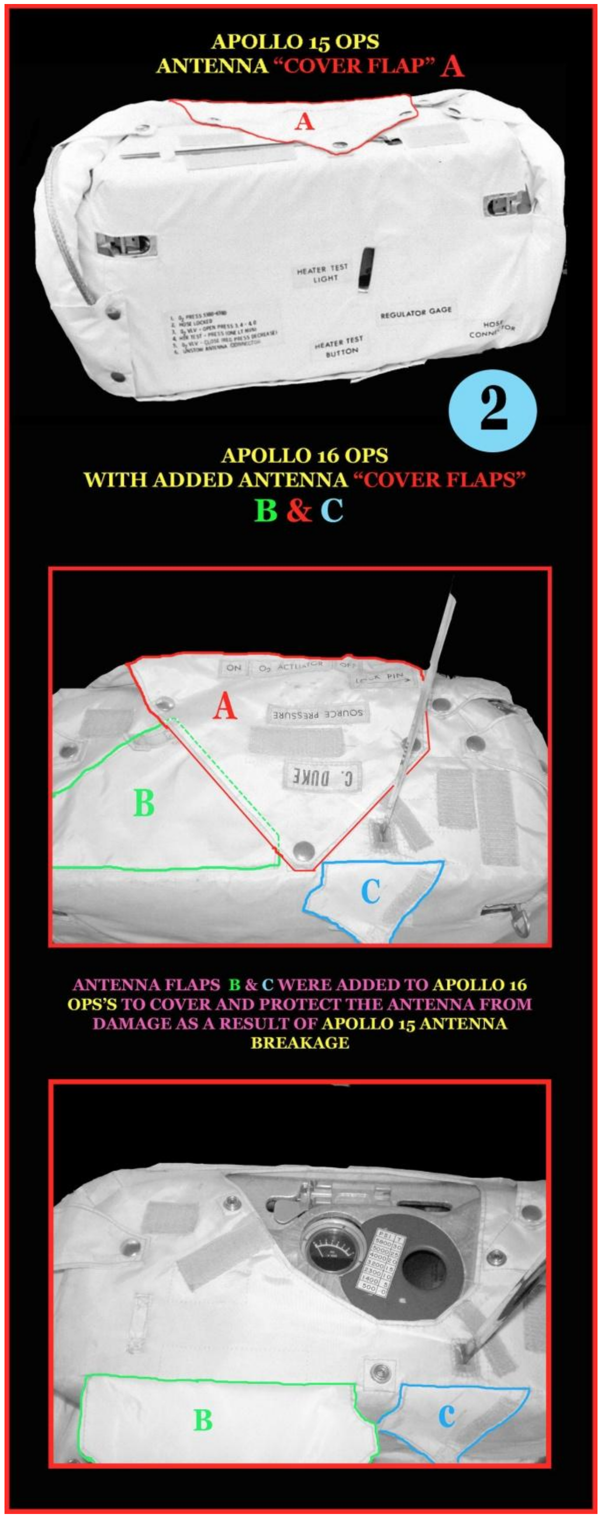
Prior to EVA #2, Scott noticed that in addition to the previously discovered nick, the antenna broke off at the bass as depicted in Figure 1. It was speculated that Irwin broke the antenna when he stepped on the OPS prior to the second LM sleep period. This time the crew made Houston aware of the problem. Houston advised the crew to lay the antenna horizontally on top of the OPS making sure the broken antenna made contact with the remaining antenna mounting stub and then taping the pieces together leaving the antenna in the horizontal position during EVA #2.

Leaving the LMP OPS Antenna laid horizontally was deemed acceptable since communications from and to the LMP EVCS was directed through the CDR OPS EVCS and not directly to the LM/MSC. Also, the CDR and LMP were usually in close proximity of each other.



As a result of the Apollo 15 antenna problems, it was decided to modify the OPS thermal cover with the antenna completely covered (with the exception of the antenna tip) so that it was protected as much as possible from accidental damage while stowed and manipulated in the LM. To that end, two additional flaps were added to the OPS cover.

Figure 2 below shows the cover configuration for Apollo 15 with only Flap A covering the antenna resulting in significant antenna exposure. In Figure 2 I've shown added flaps B and C (added for Apollo 16 and 17) that in addition to flap A cover the entire antenna. Note that when the antenna was un-stowed in the upright position (during EVA), Flap C was left to dangle as it obviously could not be positioned over the base of the antenna with the antenna in the un-stowed upright position.



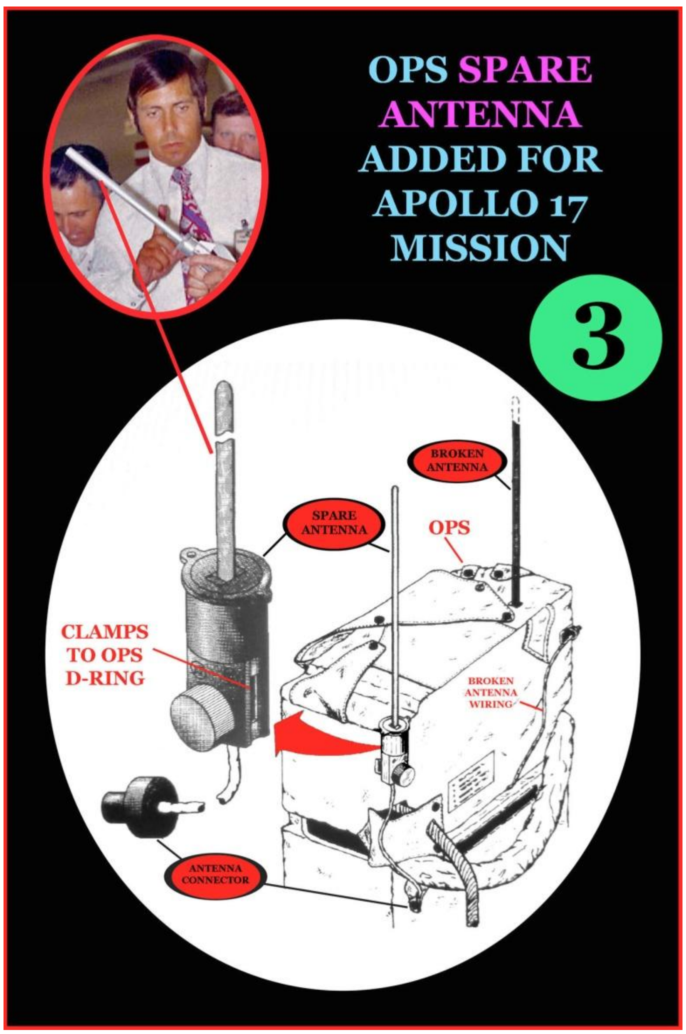
Apollo 16 Antenna Problem

Following ingress after Apollo 16 EVA #2, CDR Young and LMP Duke reported that about 2" had broken off the end of the CDR's OPS antenna. According to the crew, the CDR antenna was damaged during LM ingress as the antenna was "inadvertently" left un-stowed in the upright position. There was no possible repair for the antenna as the broken piece was missing. Since the CDR's antenna was not completely intact, and knowing that the CDR EVCS was the relay for LMP communications, it was decided that CDR Young would mount the LMP OPS with a complete antenna to the CDR PLSS with LMP Duke using the CDR OPS.

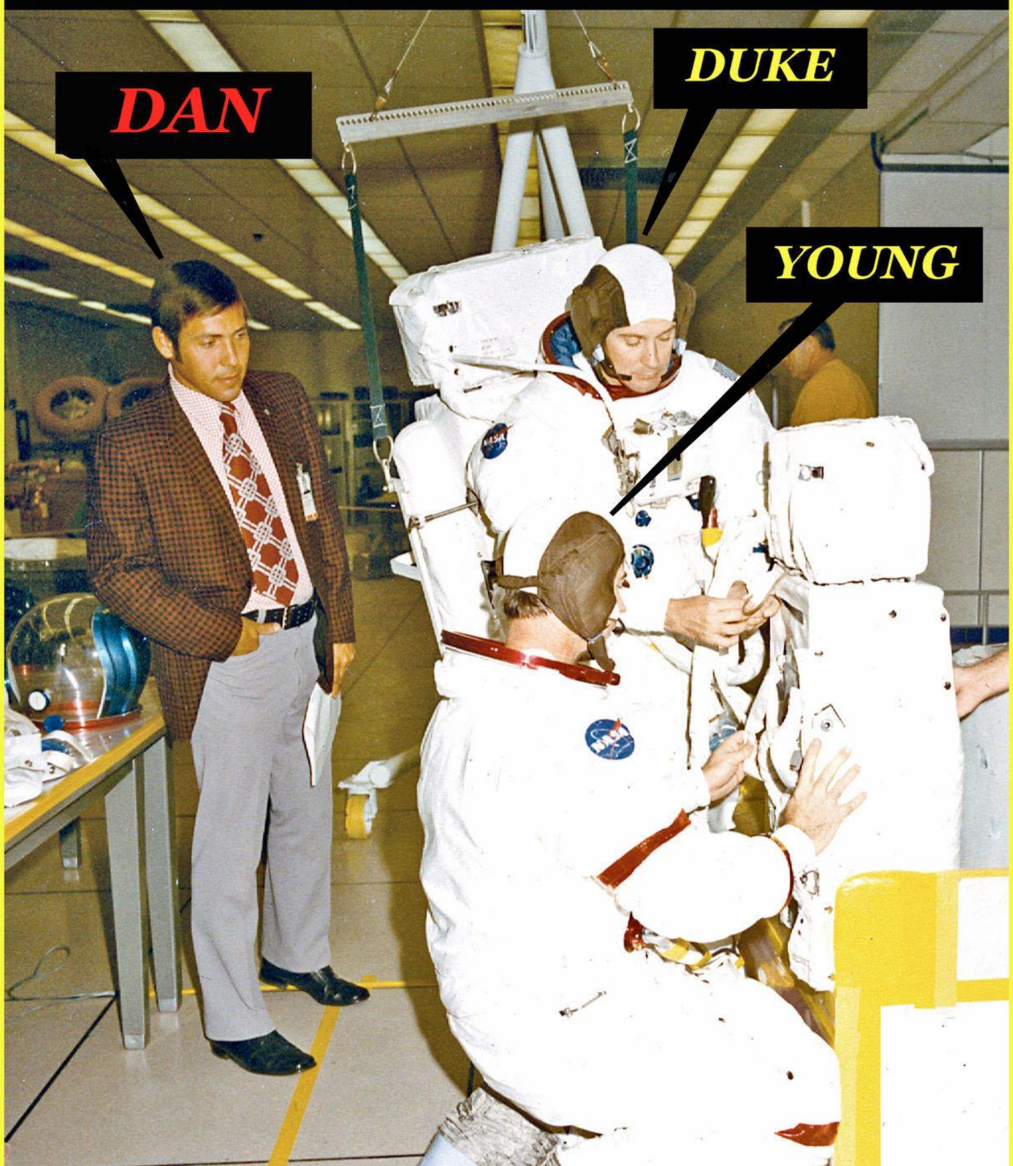
After the Apollo 16 antenna incident nothing but a procedural alert was planned for Apollo 17 LM ingress and egress. Specifically, Apollo 17 CDR Cernan and LMP Schmitt were reminded to make sure the antennas were in the stowed position during ingress and egress.

When I was made aware of the "procedural fix", I voiced my concern with respect to the possibility of a broken, damaged antenna occurring during one of the three EVA's. I voiced my concern based on my experience with antenna damage during KSC EVA training and the known vulnerability of the "flimsy" antennas. I proposed a solution that ultimately resulted in the spare antenna shown in Figure 3.

One spare oxygen purge system antenna was carried on Apollo 17 and was stowed in the Buddy Secondary Life Support System bag on the lunar rover. Installation of the spare antenna would have been accomplished by clamping the antenna adapter to the oxygen purge system right hand D-ring and connecting the spare antenna coaxial connector in place of the broken antenna's connector.



DAN IS EVALUATING ASTRONAUT JOHN YOUNG'S ABILITY TO "UNSTOW THE PLSS HARNESSES" PRIOR TO EVA.



UPDATING CREW TRAINING MOCKUPS WITH MODIFICATIONS MADE TO FLIGHT HARDWARE

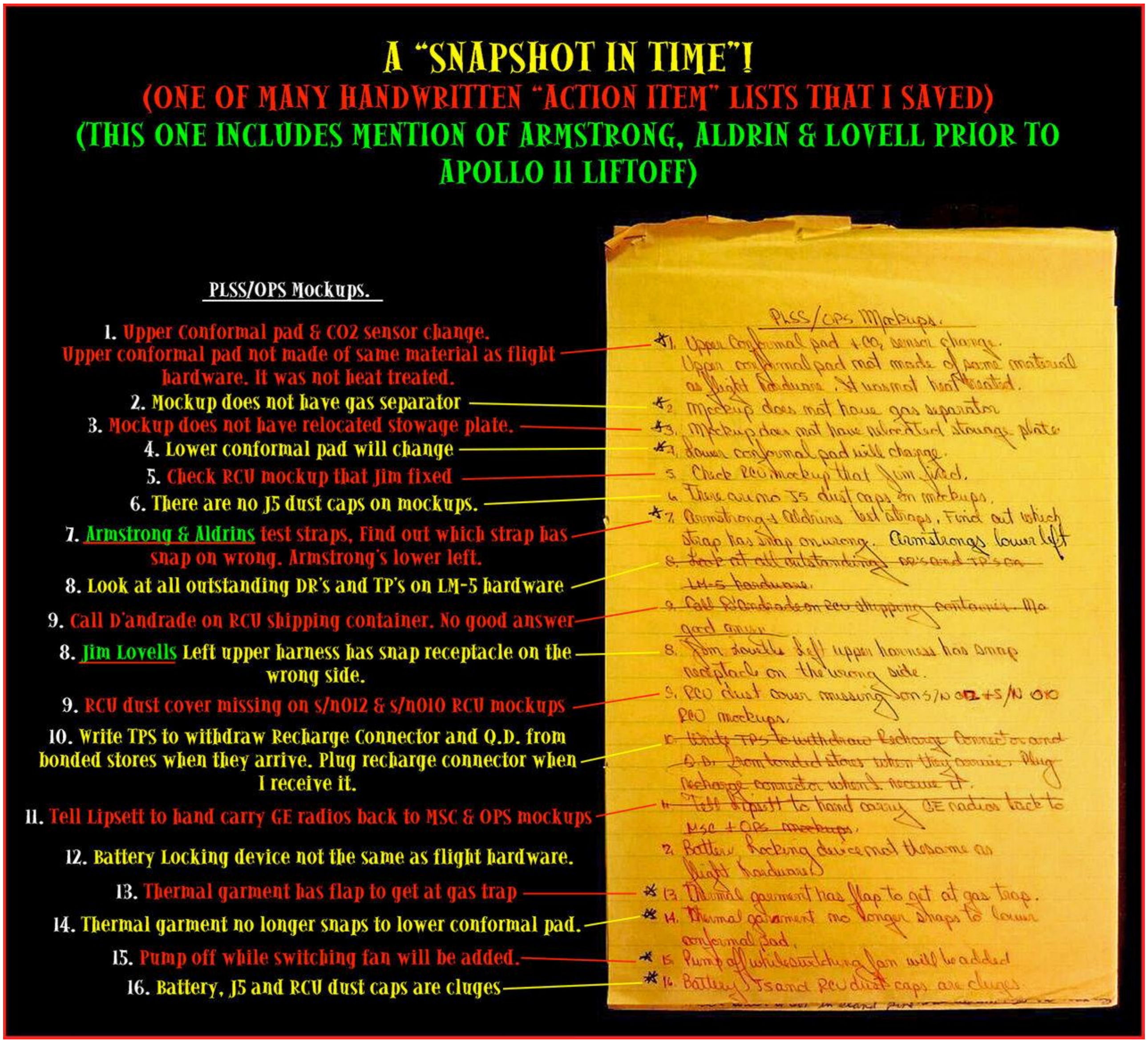
One of my responsibilities at KSC was to make sure the Crew Training PLSS, OPS and RCU mockups were identical to the flight hardware. This involved keeping track of all changes made to the flight PLSS, OPS and RCU.

Each time a change was made to the flight hardware that involved astronaut PLSS, OPS or RCU procedures, inspection, component change briefings, etc., I was responsible for implementing the change to the mockups keeping in mind that the astronauts use of the flight hardware was based on their training with the mockups.

Imagine, for instance, if a configuration change was made to the flight hardware and was not implemented in the mockups and subsequently not recognized by the crew on the moon, there might have been disastrous consequences.

The below figure is one of my many saved "action item" lists that involved keeping track of and implementing flight hardware changes to mockups.

To this day, when I look at "specific" documentation in my own handwriting I get "chills up and down my spine". I still cannot believe how lucky I was to be in the right place at the right time!



<u>CREW TRAINING WEEKLY SUMMARY REPORT</u>

Another one of my responsibilities as PLSS/OPS Mission Manager for all Apollo 11-17 missions was to write a weekly Summary Report for all crew training exercises. One report, in particular, that I vividly remember, documented the results of four (4) crew training exercises conducted the week of June 15, 1969 to June 21, 1969 (see my report below).

The first on June 18th involved a Lunar Surface EVA with Armstrong and Aldrin. The second on June 20th involved a Post-EVA exercise with Apollo 11 backup astronauts Lovell and Haise in the morning and the third, a Pre-EVA exercise with Armstrong and Aldrin in the afternoon.

The fourth and last exercise for the week involved Armstrong and Aldrin on June 21st. I found the below photo with Armstrong related to the June 21st exercise. The second underlined sentence on Page 2 of the below memo, i.e. "The astronauts performed the feedwater collection procedure for the first time" relates to Armstrong performing the procedure on June 21, 1969 less than a month before liftoff.

As an aside, the "Feedwater Collection Procedure" involved collecting any remaining water in the PLSS feedwater reservoir tank. Using the amount of the remaining feedwater, a calculation could be made (using previous manned chamber PLSS testing that graphically plotted Astronaut Metabolic heat output vs feedwater usage) to determine the metabolic work load of both Armstrong and Aldrin after completion of their EVA. (The feedwater was used to cool the closed loop recirculated Liquid Cooling Garment (LCG) water and also cool the closed loop recirculated oxygen. The cooling was accomplished by the PLSS sublimator that allowed the feedwater to convert from water to ice then directly to gas as the heated LCG water and oxygen passed through the sublimator using the process of sublimation).

To collect the remaining feedwater, the astronaut connected a "feedwater collection bag" (see photo below) to the PLSS water fill connector (also shown in photo below). With the remaining water in the bag, the bag was weighed, the weight was recorded by the crew and reported to cap-com.

Can you imagine, how lucky I was to have had the incredible opportunity to be so intimately involved with every aspect of astronaut EVA training. Please pinch me!!

MEMO DAN WROTE AS "PLSS/OPS MISSION MANAGER" SUMMARIZING THE RESULTS OF APOLLO 11 CREW TRAINING EXERCISES CONDUCTED ON JUNE 18th, 20th AND 21st, 1969 LESS THAN ONE MONTH BEFORE APOLLO 11 LIFTOFF ON JULY 16,1969.

PAGE 1

Hamilton Standard DIVISION OF UNITED AIRCRAFT CORPORATION UA

INTERNAL CORRESPONDENCE

June 23, 1969

Memorandum to Messrs: J. Beggs
M. Horton

cc to Messrs: J. Ellzey
R. Mayo
E. Brisson
F. Goodwin
E. Young
M. Carson
F. Savage
E. Trares
C. Castle

Subject: LM-5 Crew Training Exercises

Enclosed for your information is a summary of LM-5 Crew Training activities held during the week of June 15, 1969 to June 21, 1969.

Please contact the undersigned for additional information or comments on this report.

D. Schaiewitz
D. Schaiewitz
LM-5 PLSS/OPS Mission Manager

C. Brisson
E. Brisson
Project Manager
KSC Operations

PAGE 2

On June 18, 1969 HSD/KSC supported a Lunar Surface EVA exercise with astronauts "Buzz" Aldrin and Neil Armstrong the participants. During the 2 hour and 15 minute exercise, the astronauts Life Support System was the HSD/MSC built cryogenic backpacks. Both the backpacks operated for the length of the exercise. At the conclusion of the exercise, Astronaut Armstrong reneged on a previous approval of the RCU Camera bracket angle and requested a 15° decrease in the angle the camera makes with the horizontal.

On June 20, 1969 HSD/KSC supported a Post-EVA exercise with backup astronauts James Lovell and Fred Haise. A Pre-EVA exercise with astronauts Aldrin and Armstrong was also conducted later that day. During the Post-EVA exercise, the astronauts doffed the two PLSS/OPS's, checked out the OPS's for contingency transfer, jettisoned the PLSS's and performed the newly added Feedwater Collection procedure. The Pre-EVA exercise included PLSS/OPS checkout and donning. Everyone concerned was pleased with the performance of the PLSS, OPS and RCU mockups during both the Pre and Post EVA runs.

Astronauts Aldrin and Armstrong successfully completed a Post-EVA exercise on June 21, 1969. The astronauts perfomed the feedwater collection procedure for the first time. Before the exercise began the astronauts were informed by NASA Crew Systems Division that it was possible to increase the camera bracket angle to 20°, without jeopardizing the loading and unloading of the camera magazine. As a result, the camera bracket angle will be changed to 20°.


FEEDWATER COLLECTION PROCEDURE (BELOW) REFERRED TO IN MY ABOVE "LM-5 CREW TRAINING EXERCISES" MEMO
APOLLO 11 CDR ARMSTRONG
NASA
PLSS FEEDWATER FILL CONNECTOR
FEEDWATER COLLECTION BAG

POFILE OF ASTRONAUT JOHN YOUNG

Astronaut John Young was involved in three Apollo missions, i.e. Apollo 13 as Backup CDR, Apollo 16 as CDR and Apollo 17 as Backup CDR.

John Young was a very confident individual. John went about his EVA procedures with "robot" like execution. John very rarely asked questions as he was able to remember his tasks after his first exposure to them.

John might have "cracked" a smile now and then but if he did I was not witness to it. John's serious look as seen in the below photos was representative of John as I remember him.

John was somewhat intimidating. If a mistake was made or John was not happy with something his "evil eye" look was all that was needed to express his displeasure.

There really is not much more I can say about John Young other than his acceptance to the elite Astronaut "fraternity" and successful Gemini, Apollo and STS missions "says it all".

JOHN YOUNG AS APOLLO 13 BACKUP CDR

JOHN YOUNG AS APOLLO 16 COMMANDER

ASTRONAUT EVA CREW TRAINING AND HEART IRREGULARITIES

There were no additional precautions put into place for Apollo 16 and 17 EVA Crew Training at KSC.

It might surprise you to note that if a crew member did in fact have underlying heart irregularities that could have been detected with continuous EKG monitoring (during EVA training), the irregularity(s) would "more likely" have been discovered if the astronauts had been wearing their Bio-Med belts with continuous EKG sensor monitoring.

However, there was no requirement for the crew to wear their Bio-Med belt with Bio-Med sensor EKG data monitoring during EVA Crew Training! This always bothered me especially after reading the Apollo 15 Final Report with the reported heart irregularities.

Heart irregularities would "more likely" have been discovered with EVA training EKG monitoring as EVA training required expending considerably more energy (compared to Lunar EVA activity) resulting in considerably greater metabolic load on the heart for the following reasons:

- PLSS/OPS/PGA earth weight was 180 lbs. Lunar weight was 30 lbs. I can reduce the earth weight figure since we used lighter weight PLSS's called Cryopacks which reduced the EVA EMU Earth weight from 180 to 156 lbs vs. the 30 lb Lunar weight. Conclusion: 156 - 30 = 126 additional lbs = additional expendable energy with resulting increased metabolic load on the heart.

- Minimal suit cooling capability using EVA Crew Training Cryopacks relying on suit ventilation cryogenic air cooling rather than adequate PLSS LCG cooling since the PLSS cooling capability only functioned in a vacuum using the process of sublimation. Eventually, I did design a cooling capability using melting ice circulated through the LCG, however, we were never able to equal the cooling capabilities of the PLSS sublimator. Minimal cooling capabilities in the Florida heat equated to increased metabolic load.

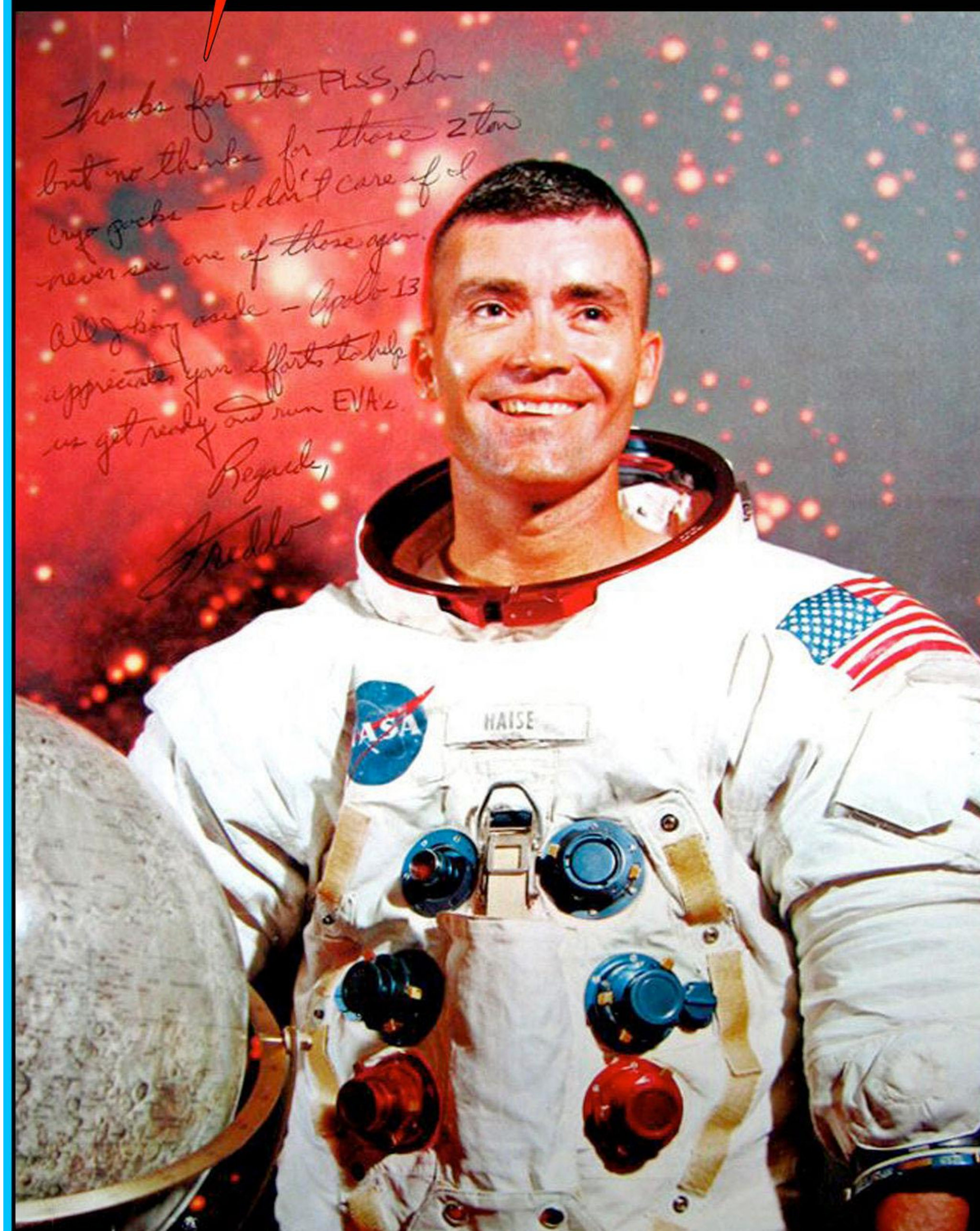
DID THE ASTRONAUTS EXPEND MORE ENERGY DURING CREW TRAINING (WITH EARTH WEIGHT EMU'S AND INADEQUATE SUIT COOLING CAPABILITY) THAT MIGHT HAVE RESULTED IN FINDING UNDERLYING HEART IRREGULARITIES WITH CREW TRAINING EKG MONITORING?
JUST ASK APOLLO 13 ASTRONAUT FRED HAISE. BUT, PLEASE, DON'T MENTION THE WORD "CRYOPACK" !!!

IN ASTRONAUT HAISE'S OWN WORDS

THANKS FOR THE PLSS, DAN BUT NO THANKS FOR THOSE 2 TON CRYOPACKS - I DON'T CARE IF I NEVER SEE ONE OF THOSE AGAIN. ALL JOKING ASIDE - APOLLO 13 APPRECIATES YOUR EFFORTS TO HELP US GET READY AND RUN EVA's

REGARDS,

FREDDO



DEVICE BUILT TO HELP SIMULATE PLSS/OPS 1/6 G LUNAR WEIGHT

Before astronaut EVA crew training was assigned to KSC, there were reported problems in accurately determining the custom fixed lengths for the PLSS (Portable Life Support System) backpack harnesses (straps) that connected and secured the PLSS to the PGA (spacesuit Pressure Garment Assembly). Note that the PLSS harness lengths were custom sized for each astronaut.

The reported problem was that the sizing process did not take into account the heavier Earth weight of the PLSS/OPS at 125 lbs. vs. the 1/6 "G" lunar weight at 20.8 lbs. resulting in the Earth weight PLSS/OPS mockups and flight PLSS/OPSs when worn during crew fit and function testing and PLSS/OPS donning and doffing procedures resting lower on the astronaut's back than on the lunar surface.

As a result, there was no way to confirm that access to PLSS controls (Oxygen on/off, Diverter valve control, Feed water on/off) would have been identical on the moon. Note that the PLSS controls were located in the lower right hand corner of the PLSS with the astronaut "blindly" reaching behind for control access. The heavier earth weight PLSS/OPS also, did not give the astronaut an accurate lunar simulation with respect to location, movement and "feel" of the PLSS while performing tasks.

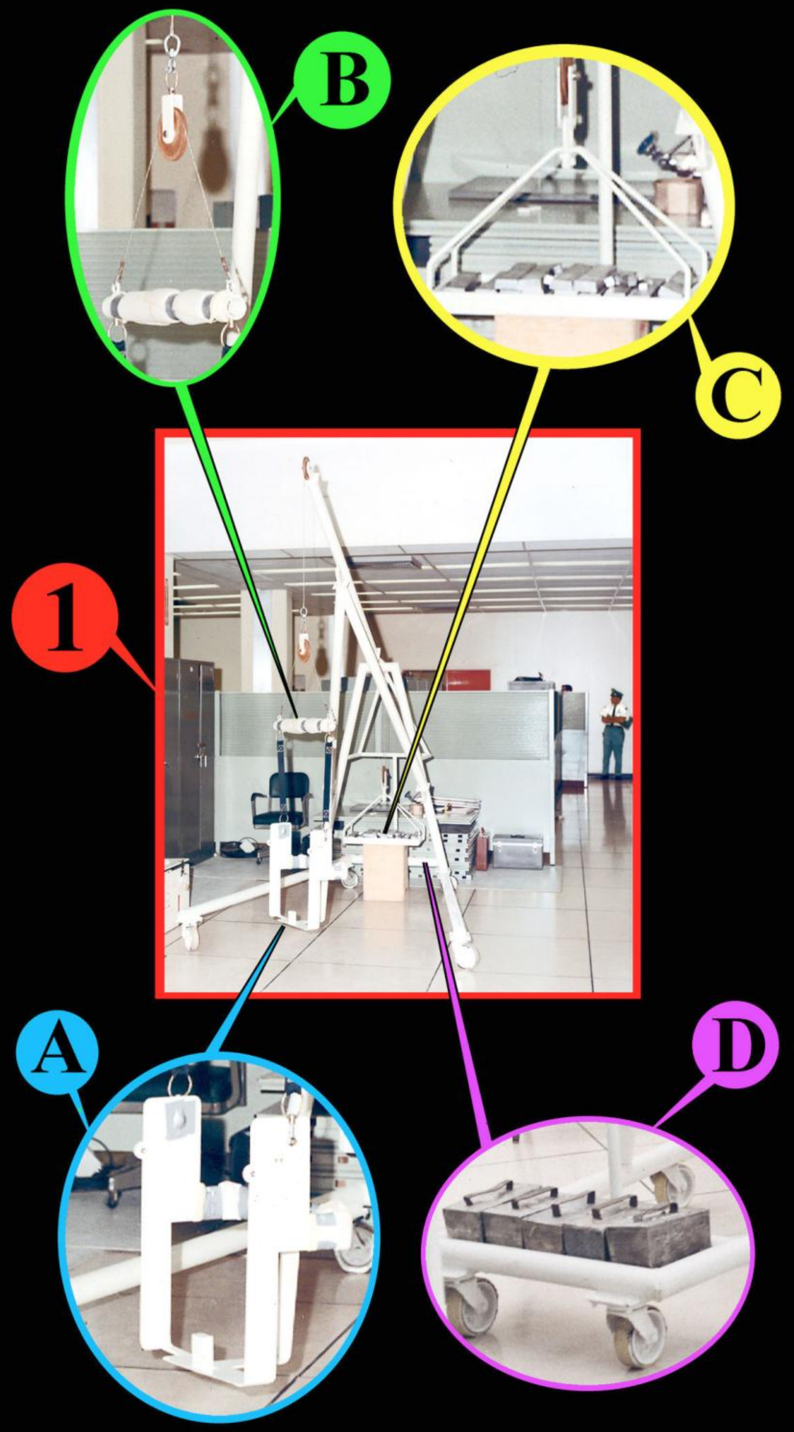
Being aware of the problem identified at MSC and knowing that astronaut EVA training was being moved to KSC on June 1, 1969, I thought of a possible solution that would both solve the problem of determining accurate custom harness lengths and being able to evaluate the harness lengths, PLSS location, movement and "feel" using lunar weight PLSSs. To that end, I came up with the idea of a counterbalance on wheels, sketched it out and asked the GE Support group at KSC (GE had the Ground Support Equipment contract during Apollo) if they would build my design concept.

After getting approval from NASA Crew Systems Division we (myself and members of the GE Support team) created the PLSS/OPS 1/6 "G' "counter balance" shown in the below graphic. The counter balance is identified as #1 in the graphic. Inserts A, B, C, and D represent specific features of the unit.

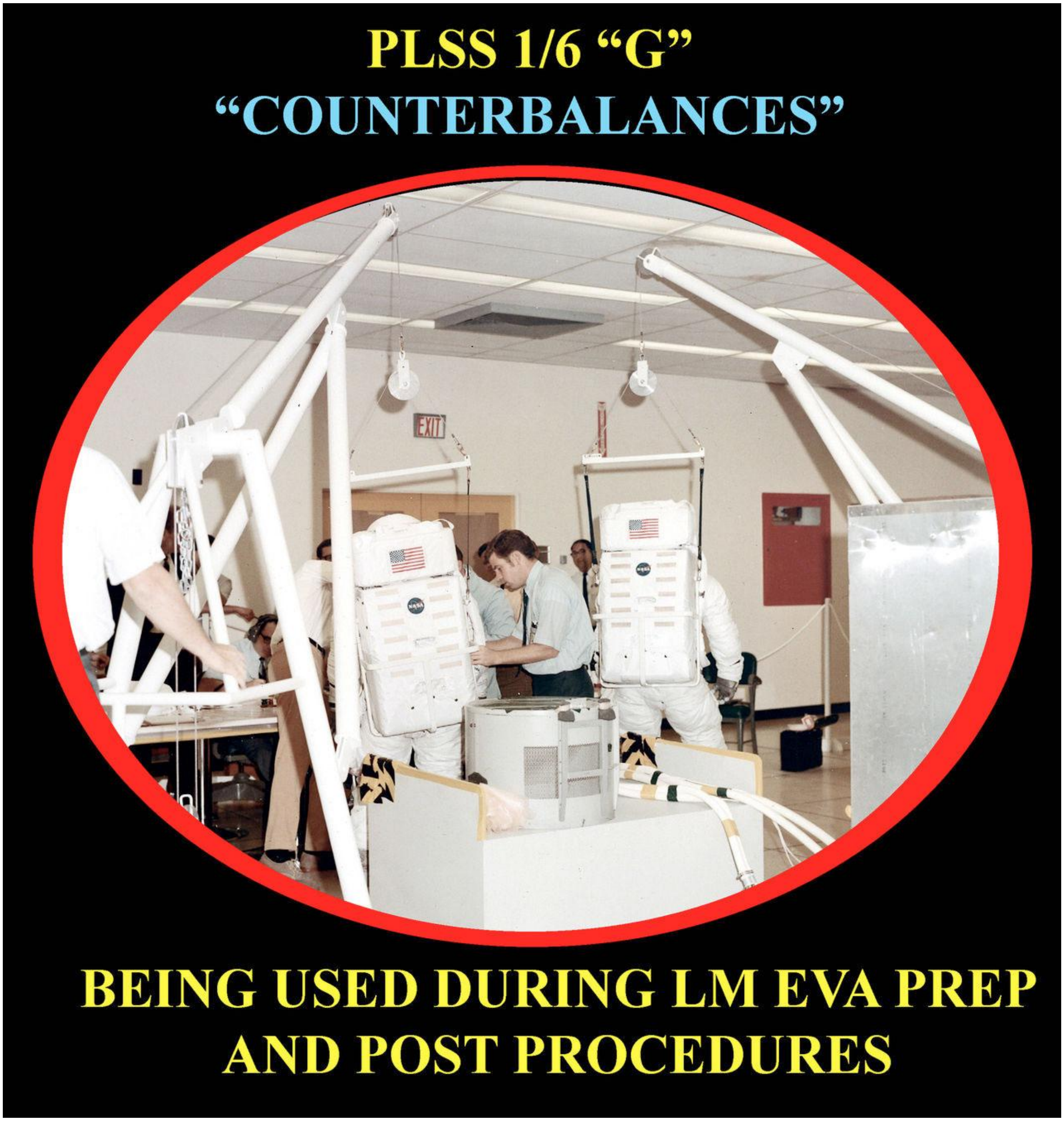
Insert A shows the "cradle" mount that held and supported the PLSS/OPS. Insert B shows the cradle being supported by a pulley that allowed PLSS lateral motion. Insert C shows a counterbalancing weight holder that supported 5/6 the weight of the PLSS/OPS at 104 lbs.(5x20.8). The weights can be seen in the weight holder of Insert C. To prevent the entire unit from tipping over we built a "tray" to hold large weights seen in Insert D.

The unit did, in fact, accomplish the goals that I established for it and it was an incredible Apollo project that I was proud and excited to have played the primary role in. I can't repeat enough times how lucky I was to have been in the right place at the right time to "live a dream."

PLSS/OPS
1/6 "G"
"COUNTER BALANCE"



Following are photos of the 1/6 "G" Counterbalance:



“BUZZ” ALDRIN WITH PLSS/OPS MOUNTED IN “COUNTERBALANCE” CRADLE

DAN WITH PLSS/OPS MOUNTED IN "COUNTERBALANCE" CRADLE

"COUNTERBALANCE" CRADLES

DAN

EVALUATING THE SPACE SUIT PURGE VALVE

In the photo below I'm evaluating a newly designed PGA "Dual Position Purge Valve" incorporated for the Apollo 14 and subsequent missions. Purge valve design for previous Apollo missions had only one purge flow capability of 8lb/hr.

The Purge Valve is used in conjunction with the Oxygen Purge System (OPS) in the event that the PLSS can no longer provide oxygen to the suit or if there is a "contaminant control malfunction (unable to provide carbon dioxide "washout") or if there is a suit leak.

The Purge Valve is inserted in the red unused gas connector (LM O2 outlet umbilical connector) during EVA. The Purge Valve can be set to two flow positions, i.e. "LO" and "HI" (reference below graphic).

In the LO flow position, a flow of 4lb/hr provides breathing oxygen and adequate CO2 washout when additional cooling is not required, i.e. failed PLSS O2 supply and working PLSS cooling. The low flow capability was added for Apollo 14 also to be used in conjunction with the Buddy Secondary Life Support System (BSLSS) which was also first incorporated for Apollo 14.

When using the BSLSS with a failed PLSS water cooling capability, the astronaut with the BSLSS cooling needs only breathable oxygen and CO2 washout with 4lb/hr Purge Valve flow (LO flow position).

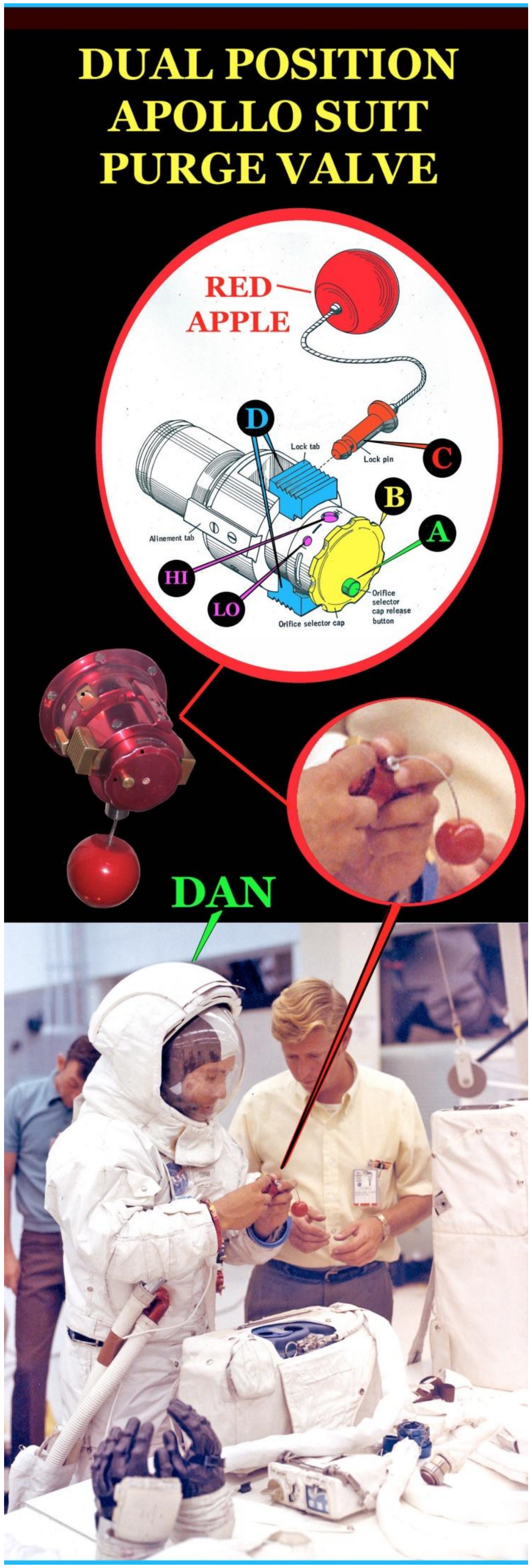
In the HI flow position, the Purge Valve allows an 8lb/hr flow for breathable O2, CO2 washout and "some" cooling (obviously little cooling compared to PLSS LCG cooling) with a failure of PLSS breathable O2 and water cooling.

Once the Purge Valve flow position is set (LO or HI) the valve is activated by removing the locking pin "C" by pulling the "Red Apple" and then depressing the two activation tabs "D".

In the below photo, I was specifically concerned about the capability of the suited astronaut with EVA gloves to change the Purge Valve positions. To accomplish a position change, the orifice selector cap release button "A" is depressed and the orifice selector cap "B" is rotated to the desired position.

As you can see in the photo I did not have on my EVA gloves and, of course, I was able to change Purge Valve positions with no problem. At this point in the exercise I told my NASA engineer counterpart that during one of the upcoming EVA crew donning and doffing exercises the crew should practice Purge Valve flow position changes pressurized with EVA gloves on.

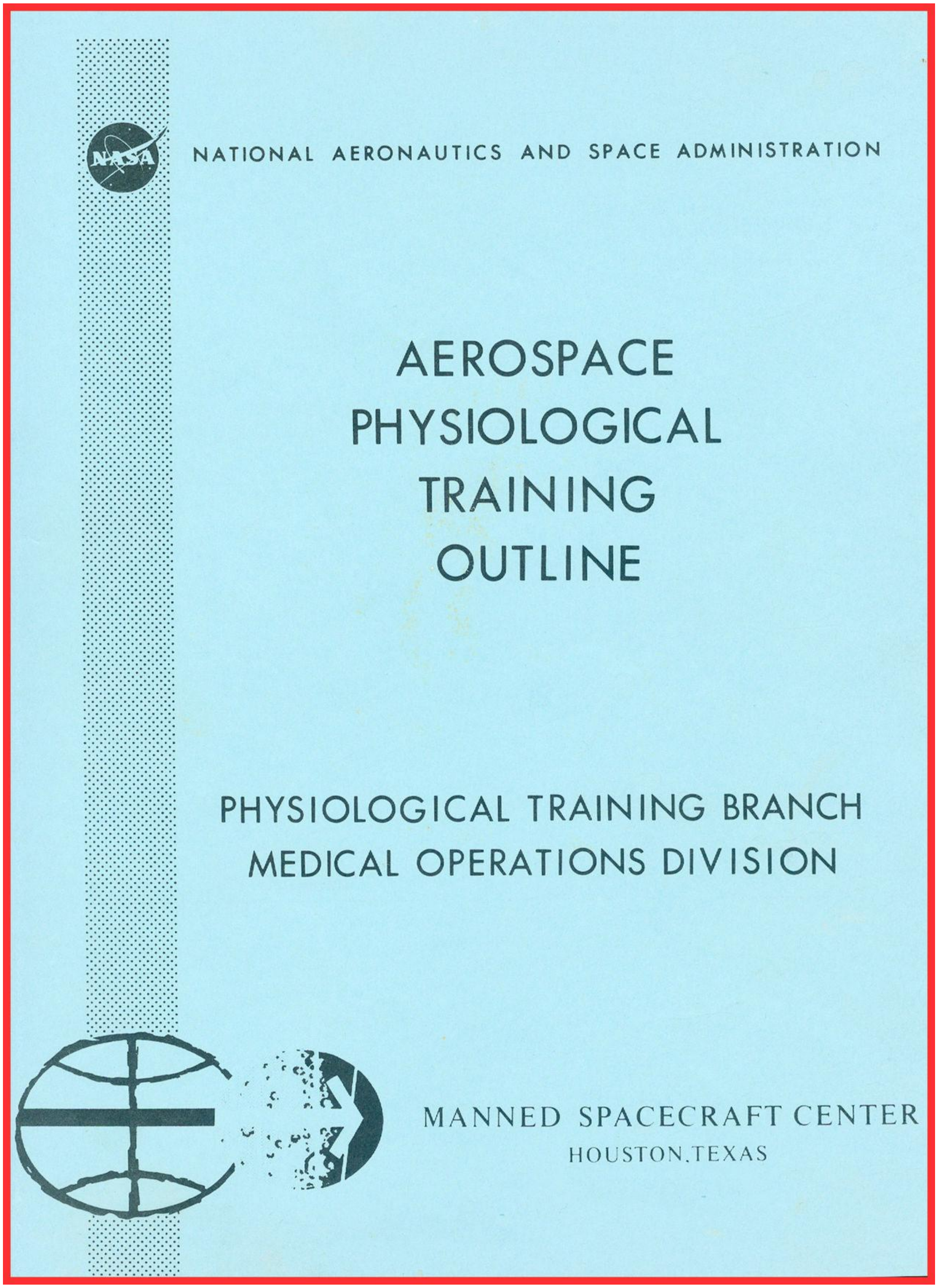
I'm glad I made the suggestion as both Apollo 14 astronauts Shepard and Mitchell had difficulty with the position change and "played" with it until they felt confident they could do it. It's interesting to note that both astronauts did not like the design!


DUAL POSITION
APOLLO SUIT
PURGE VALVE
RED
APPLE
D
Lock tab
Lock pin
C
B
A
Alinement tab
HI
LO
Orifice selector cap
Orifice
selector
cap release
button
DAN

<u>MY PHYSIOLOGICAL TRAINING IN PREPARATION FOR SPACE SUIT TESTING</u>

One of the most memorable days during my Apollo journey was the day I was asked if I wanted to be a "suit subject" allowing me to wear and test astronaut space suits. Was there any doubt what my answer would be!

There was, however, one requirement before I was officially given the title of "suit subject". I had to attend a class called "Physiological Aerospace Training Outline" (cover below) that included the topics in Figure 2 below.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AEROSPACE PHYSIOLOGICAL TRAINING OUTLINE

PHYSIOLOGICAL TRAINING BRANCH
MEDICAL OPERATIONS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

AEROSPACE PHYSIOLOGICAL TRAINING OUTLINE

OBJECTIVE: To familiarize personnel who are exposed to a lowered barometric pressure with the physiological stresses encountered and how to successfully overcome these stresses.

COURSE CURRICULUM

2

I. Test Chamber Personnel:

- A. Physics of the Atmosphere
- B. Respiration and Circulation
- C. Hypoxia and Hyperventilation
- D. Decompression Sickness
- E. Chamber Flight
- F. Examination and Critique

I PAID PARTICULARLY CLOSE ATTENTION TO THE SYMTOMS OF HYPOXIA AND HYPERVENTIL-ATION AS THEY WERE MOST CLOSELY RELATED TO MY SUIT TESTING PROCEDURES

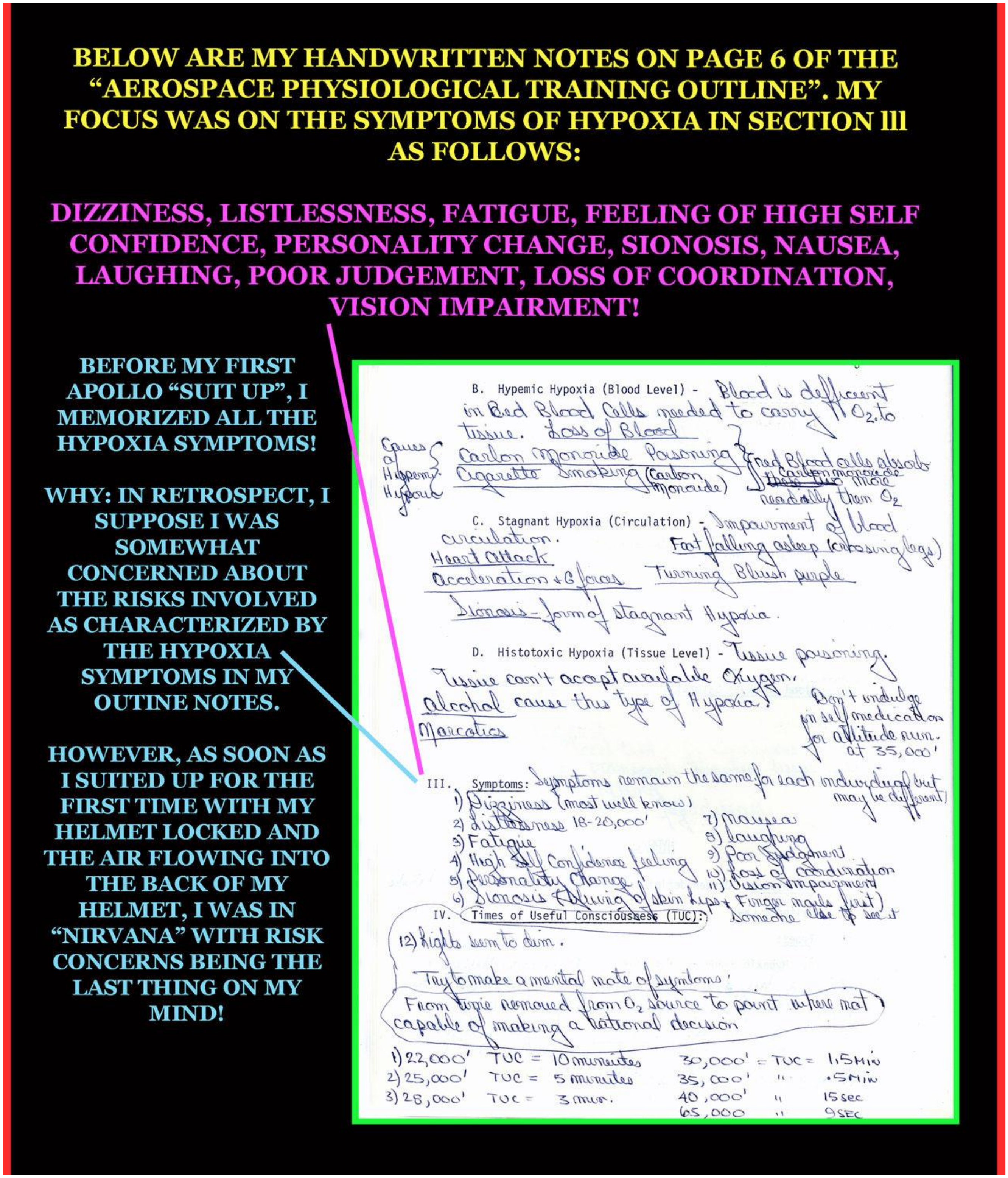
II. Flying Personnel (Refresher):

- A. Hypoxia and Hyperventilation
- B. Decompression Sickness
- C. Oxygen Equipment
- D. Escape from Aircraft
- E. Chamber Flight
- F. Examination and Critique

III. Passenger Personnel:

- A. Physics of the Atmosphere
- B. Respiration and Circulation
- C. Hypoxia and Hyperventilation
- D. Decompression Sickness
- E. Oxygen Equipment
- F. Noise and Vibration
- G. Escape from Aircraft
- H. Acceleration
- I. Chamber Flight
- J. Examination and Critique

What were my thoughts after the course and just before suiting up for the first time (see below):



B. Hypemic Hypoxia (Blood Level) - Blood is defficient in Red Blood Cells needed to carry O_2 to tissue. Loss of Blood

Causes of Hypemic Hypoxia: Carbon Monoxide Poisoning; Cigarette Smoking (Carbon Monoxide) — red Blood cells absorb Carbon monoxide more readilly than O_2

C. Stagnant Hypoxia (Circulation) - Impairment of blood circulation.
Heart attack
Acceleration + G forces
Foot falling asleep (crossing legs)
Turning Bluish purple
Sionosis - form of stagnant Hypoxia.

D. Histotoxic Hypoxia (Tissue Level) - Tissue poisoning.
Tissue can't accept available Oxygen.
Alcohol cause this type of Hypoxia.
Narcotics
Don't indulge in self medication for altitude run. at 35,000'

III. Symptoms: Symptoms remain the same for each individual but may be different
1) Dizziness (most well know)
2) Listlessness 18-20,000'
3) Fatigue
4) High Self Confidence feeling
5) Personality Change
6) Sionosis (Bluing of skin lips + Finger nails first) Someone else to see it
7) Nausea
8) Laughing
9) Poor Judgment
10) Loss of coordination
11) Vision Impairment
12) Lights seem to dim.

IV. Times of Useful Consciousness (TUC):
Try to make a mental note of symptoms;
From time removed from O_2 source to point where not capable of making a rational decision

1) 22,000'	TUC = 10 minutes	30,000'	= TUC =	1.5 Min
2) 25,000'	TUC = 5 minutes	35,000'	"	.5 Min
3) 28,000'	TUC = 3 min.	40,000'	"	15 sec
		65,000	"	9 SEC

LUNAR EXTRAVEHICULAR VISOR ASSEMBLY (LEVA)

The Lunar Extravehicular Visor Assembly (LEVA) with its Sun Visor, Side Eye Shades, Center Eye Shade and Viewport Door all in their Lunar Surface EVA respective open positions was and always will be my all time first choice "symbolic" representation of the Apollo Program.

The many times I was looking outside from the inside of the Pressure Helmet Assembly (PHA) through the LEVA Protective Visor and Sun Visor I was nothing less than euphoric.

I recall the time I was going through a suited procedure with my LEVA in place and the Sun Visor Down. There was a full length mirror propped up against a table. I snuck a peek and when I saw the "gold" reflection of my LEVA Sun Visor, I felt "inspirational chills" that many of us have experienced. I will never forget that moment.

For those of you that are not entirely familiar with the LEVA and its sub-components, I've put together the below graphic.

Following is a detailed description of the LEVA components shown below.

The PROTECTIVE VISOR is an ultraviolet stabilized polycarbonate shield which affords impact, micrometeoroid, and ultraviolet ray protection. It can be positioned anywhere between the full-Up and full-Down positions and requires a force of 2 to 4 pounds for movement. The protective visor can be lowered independently of the sun visor, but cannot be raised independently with the sun visor in the Down position.

The inner surface of the polysulfone SUN VISOR has a gold coating which provides protection against light and reduces heat gain within the helmet. The visor can be positioned anywhere between the full-Up and full-Down positions by exerting a force of 2 to 4 pounds on the pull tabs. The sun visor cannot be independently lowered unless the protective visor is in the Down position, but it can be raised or lowered independently when the center eyeshade is in the full-Up position and the protective visor is in the Down position.

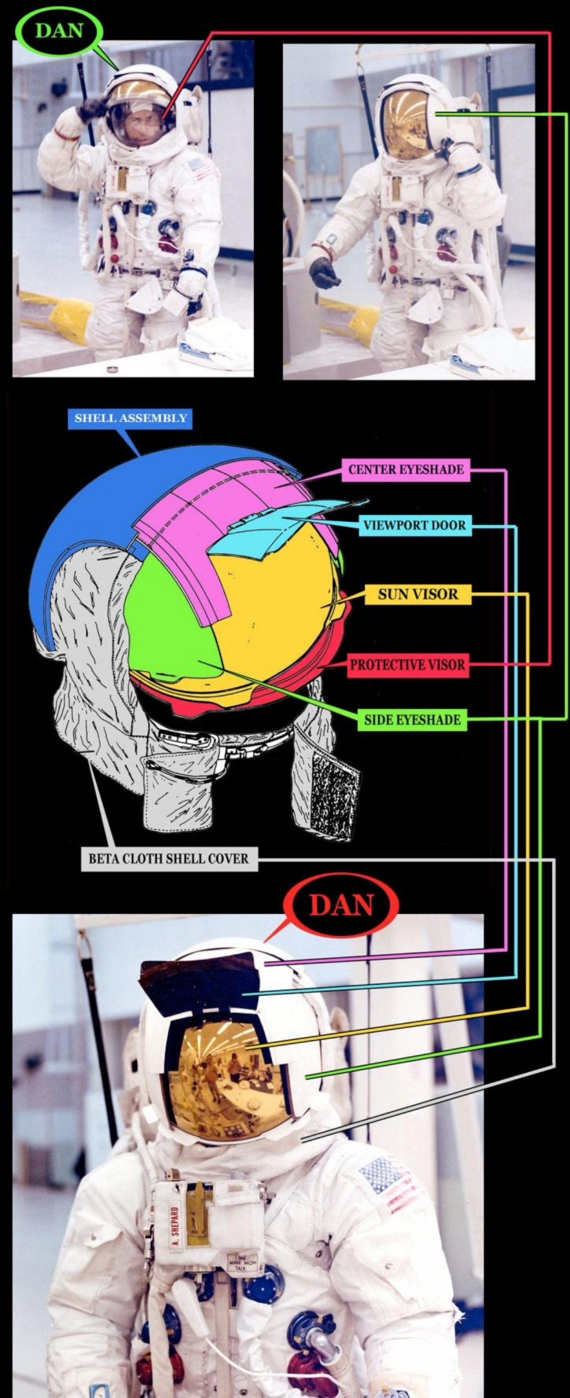
The eyeshade assemblies are constructed of fiberglass and are coated with white epoxy paint on the outer surfaces. The inner surfaces are coated with black epoxy paint.

The SIDE EYESHADES can be lowered independently of the sun visor and each other to prevent light penetration of the side viewing areas, thereby reducing low-angle solar glare.

The CENTER EYSHADE is attached to the LEVA shell assembly over the shell thermal cover and can be lowered independently of the side eyeshade assemblies. The center eyeshade assembly cannot be independently lowered unless the protective visor and the sun visor are in the down positions.

When sufficiently lowered, the VIEWPORT DOOR may be positioned as required to reduce solar glare.

DAN DEMONSTRATING THE LUNAR EXTRAVEHICULAR VISOR ASSEMBLY (LEVA)



ASTRONAUT CONSTANT WEAR GARMENT ("UNDERWEAR")

I've never been able to find photos and/or illustrative graphics that define the many Apollo Constant Wear Garment (CWG) features and their respective functions in one relatively easy to understand graphic description.

The CWG was a uniquely designed spacesuit garment that, in my opinion, was never given the "recognition" that it deserved, so, I decided to put together the following CWG detailed description.

Constant Wear Garment (CWG) Overview

The Constant Wear Garment (CWG) is a one-piece cotton undergarment that is worn next to the skin and encompasses the entire body exclusive of the head and hands. It is worn during intervehicular (IV) command module operations for general comfort, to absorb perspiration, and to hold the biomedical instrumentation system.

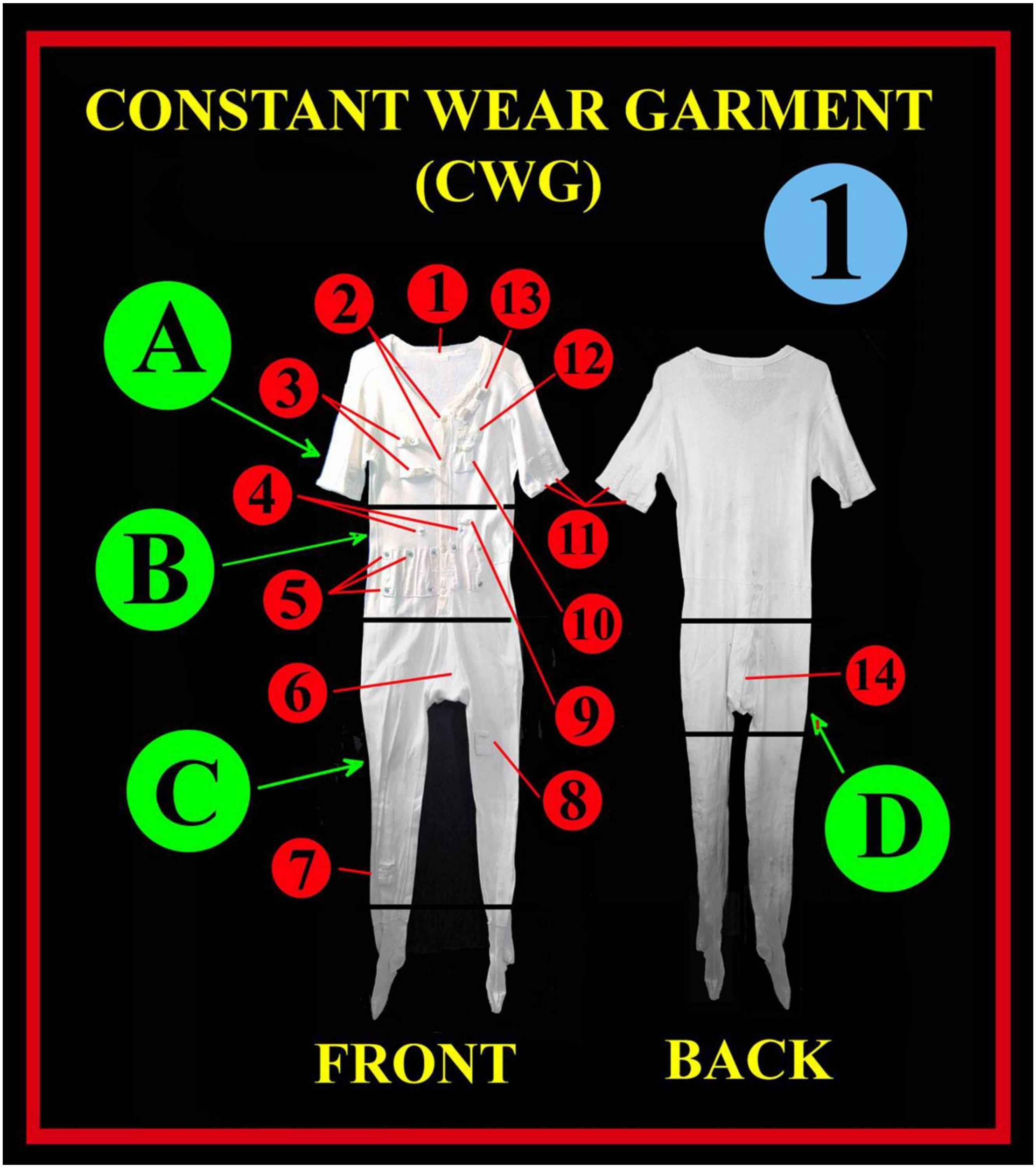
It absorbs excessive body moisture and prevents the crewman's skin from becoming chafed by the pressure garment assembly. The CWG is donned and doffed through the front opening, which is kept closed by five buttons. The feet are covered by socks sewn to the legs of the CWG.

Waste management is accommodated without removing the CWG by a fly opening in the front and a buttock port in the rear. Snap fasteners attach the biomedical instrumentation belt.

Although the CWG may be worn under either the command module pilot or extravehicular (EV) pressure garments, it is normally used during IV phases of the mission or during EVA work from the command module.

Figure 1 shows the Constant Wear Garment (CWG) Feature Identifications 1-14. Below is a description of the Figure 1 numbered features:

1. manufacturer's label
2. buttons used to open CWG front for donning and doffing
3. electrical harness connects to comm headset ("snoopy") on one end and biomed belt on the other end
4. biomedical electrodes applied to crewman's chest
5. biomedical belt connects to snaps on CWG
6. opening for urination
7. dosimeter pocket
8. dosimeter pocket
9. biomed belt connector "snap on" feed through loop
10. dosimeter
11. CWG arm fabric stiffeners
12. astronaut name tag
13. flashlight holder elastic loops
14. opening for defecation



CONSTANT WEAR GARMENT
(CWG)
1
A
B
C
D
1
2
3
4
5
6
7
8
9
10
11
12
13
14
FRONT
BACK

Figure 2 shows in detail the features of the constant wear garment top section.

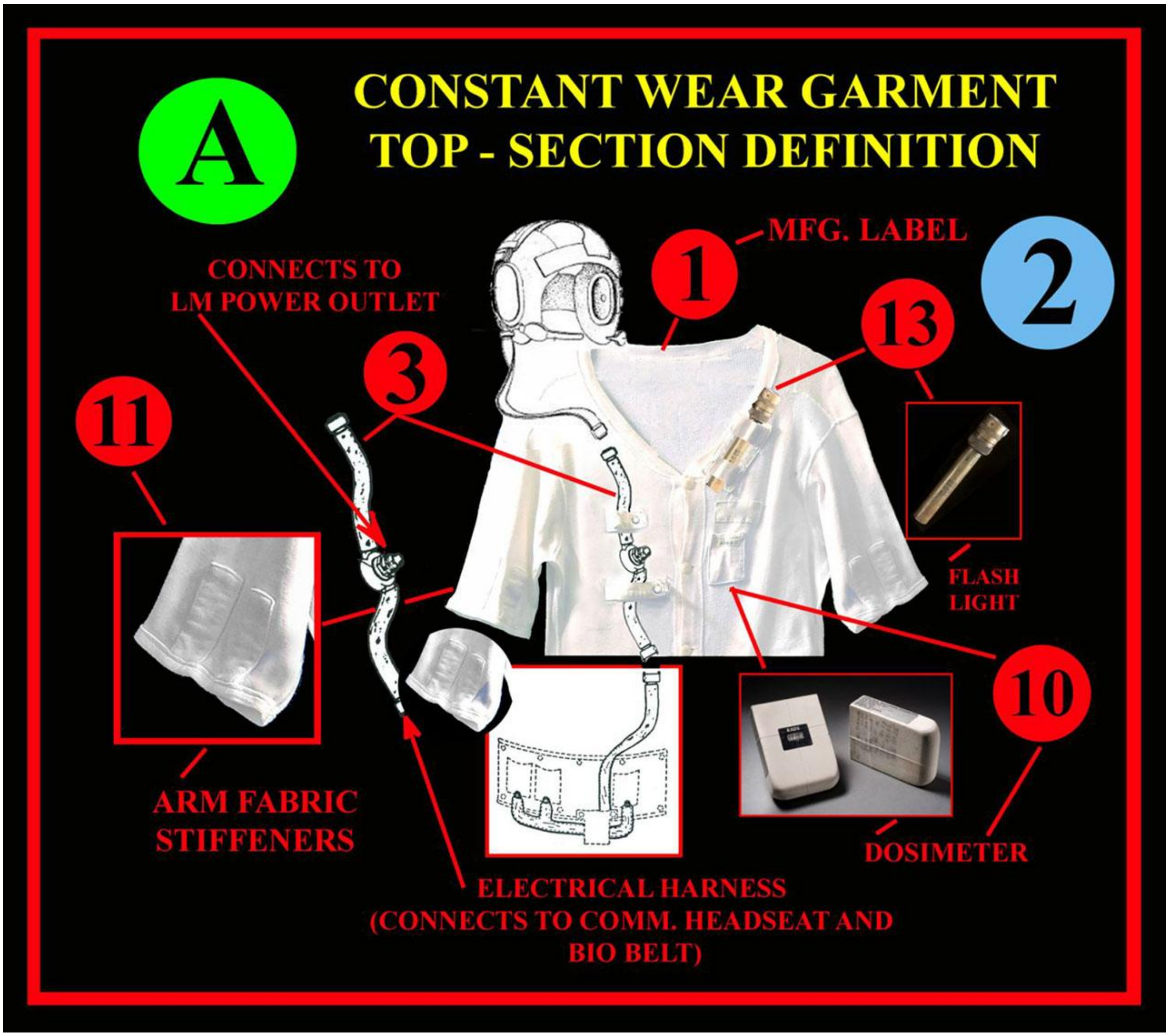


Figure 3 shows in detail the features of the constant wear garment mid-section.

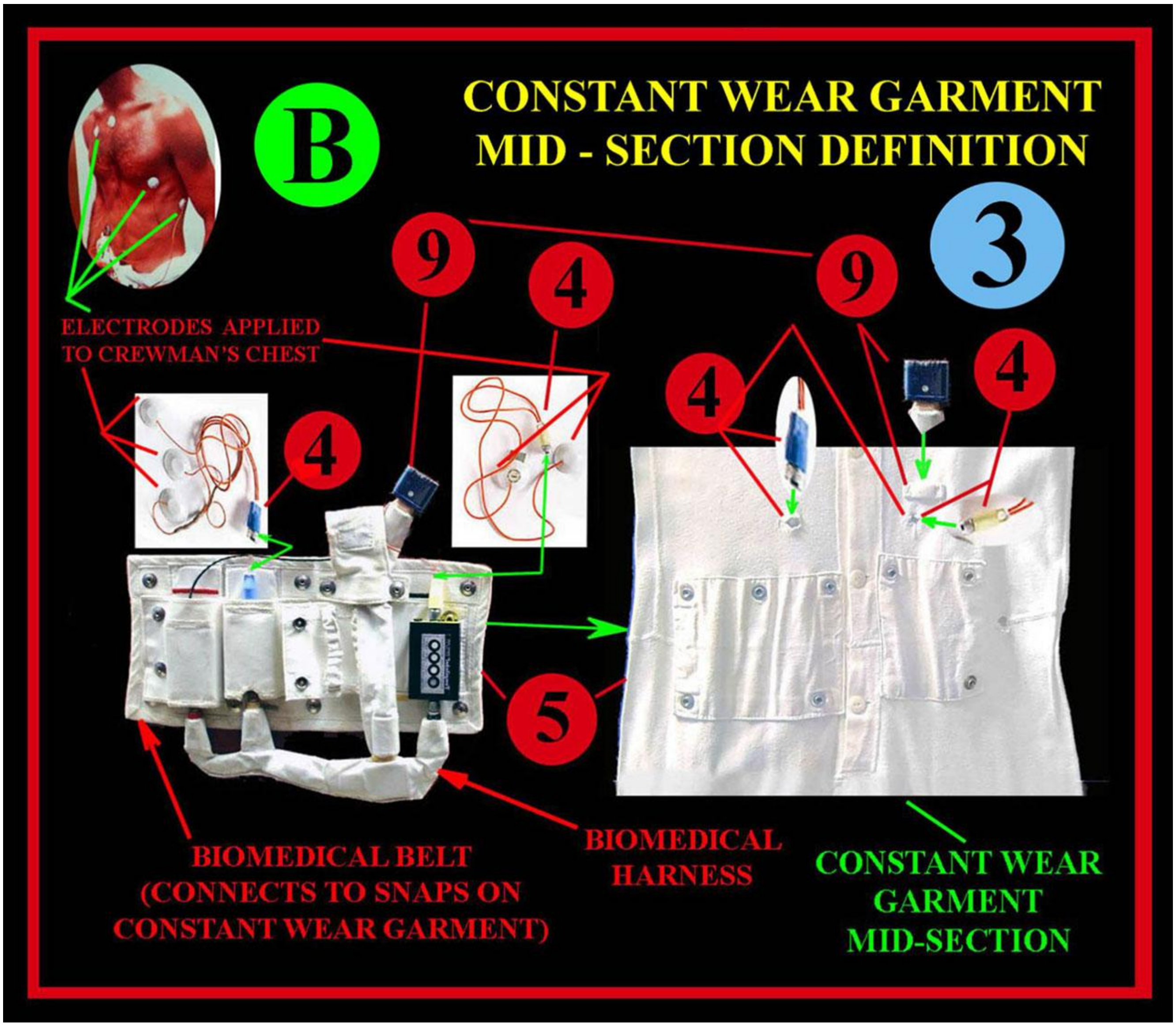
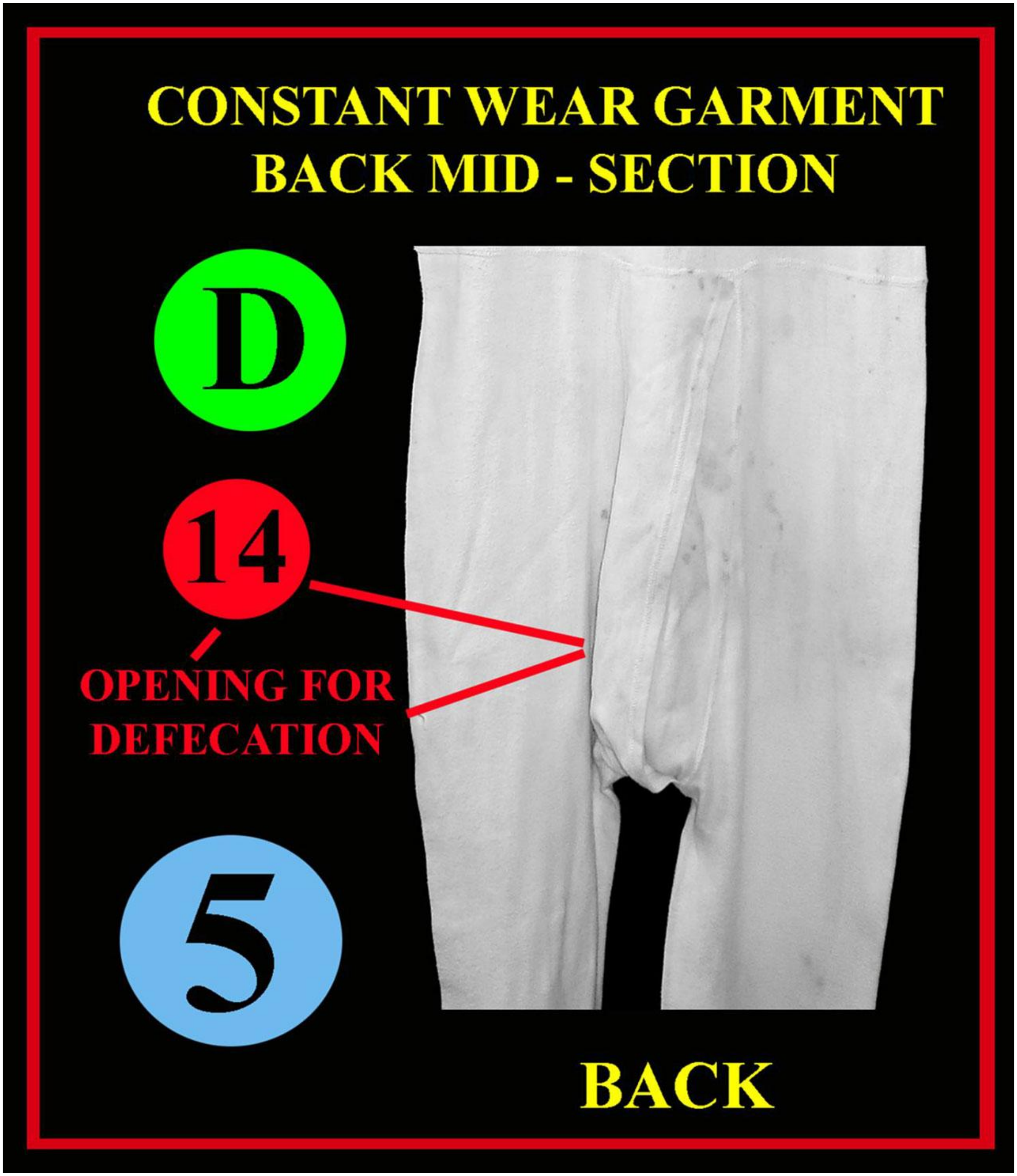


Figure 4 shows in detail the features of the constant wear garment bottom section.

Figure 5 shows the back of the constant wear garment with feature 14 (opening for defecation).



STOWING THE PLSS AND OPS'S ON THE LM FLOOR

"If you can't bring the OPS to the LM, bring the LM to the OPS. Well, not exactly!"

A very important mission requirement was hardware interface fit checks to verify hardware compatibility between different contractors. Photos 1 and 2 below represent an "interface fit check" between Hamilton Standard's Oxygen Purge System (OPS) and Grumman's lunar module (LM) floor. Also, between ILC's helmet stowage bags and Grumman's LM floor.

The first objective of the fit check was to give the Apollo commander and lunar module pilot (in this case, Apollo 13 CDR Lovell and LMP Haise) the opportunity to install both OPSs to the LM floor (Photo 1). The second objective was to confirm compatibility of the OPS mounting feet and locking pin with the LM floor.

For each mission, the OPS fit check was performed in the Kennedy Space Center crew training building. How was that possible, you might ask! As the title of the first photo suggests, "If you can't bring the OPS to the LM, bring the LM to the OPS." Specifically, bring the LM floor to the crew training building.

The stowage configuration with the two OPSs mounted to the LM floor as in the first two photos was the LM "lunar launch" configuration. Therefore, the LM lunar pre-launch stowage configuration necessitated that the crew stow the OPSs and therefore the required LM crew involvement in the OPS stowage fit check procedure.

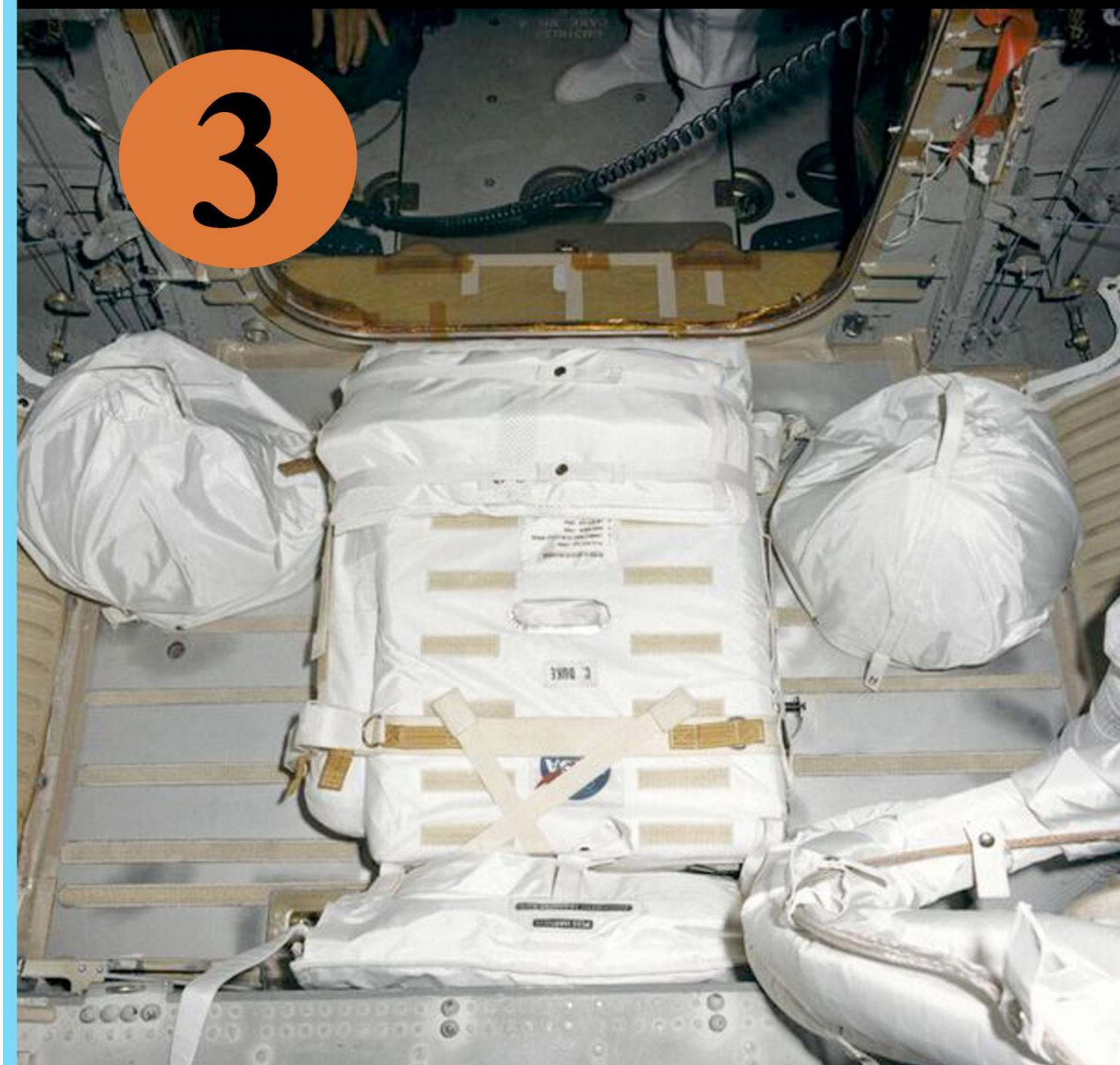
Photo 3 shows the LM floor "Earth launch" configuration with the LMP PLSS stowed on the LM floor. Fit checking the LMP PLSS to the LM floor was also performed at the same time as the OPS fit checks (note that Photo 3 shows the LMP PLSS stowed on the LM floor in the LM). The PLSS "fit check" procedure with the crew was accomplished along with the OPS fit check in the KSC crew training building. Despite the fact that the crew was not required to stow the PLSS on the LM floor after Lunar landing, they were required to remove the PLSS from the LM floor before EVA. Therefore, the crew practiced PLSS removal from the floor during the fit check.

IF YOU CAN'T BRING THE OPS TO THE LM, BRING THE LM TO THE OPS!

APOLLO 13 OPS & HELMET BAG FIT CHECK TO LM FLOOR

OPS'S STOWED ON LM FLOOR FOR "LUNAR LAUNCH"

PLSS STOWED ON LM FLOOR FOR "EARTH LAUNCH"



PLSS/OPS TRAINING "BACKPACKS"

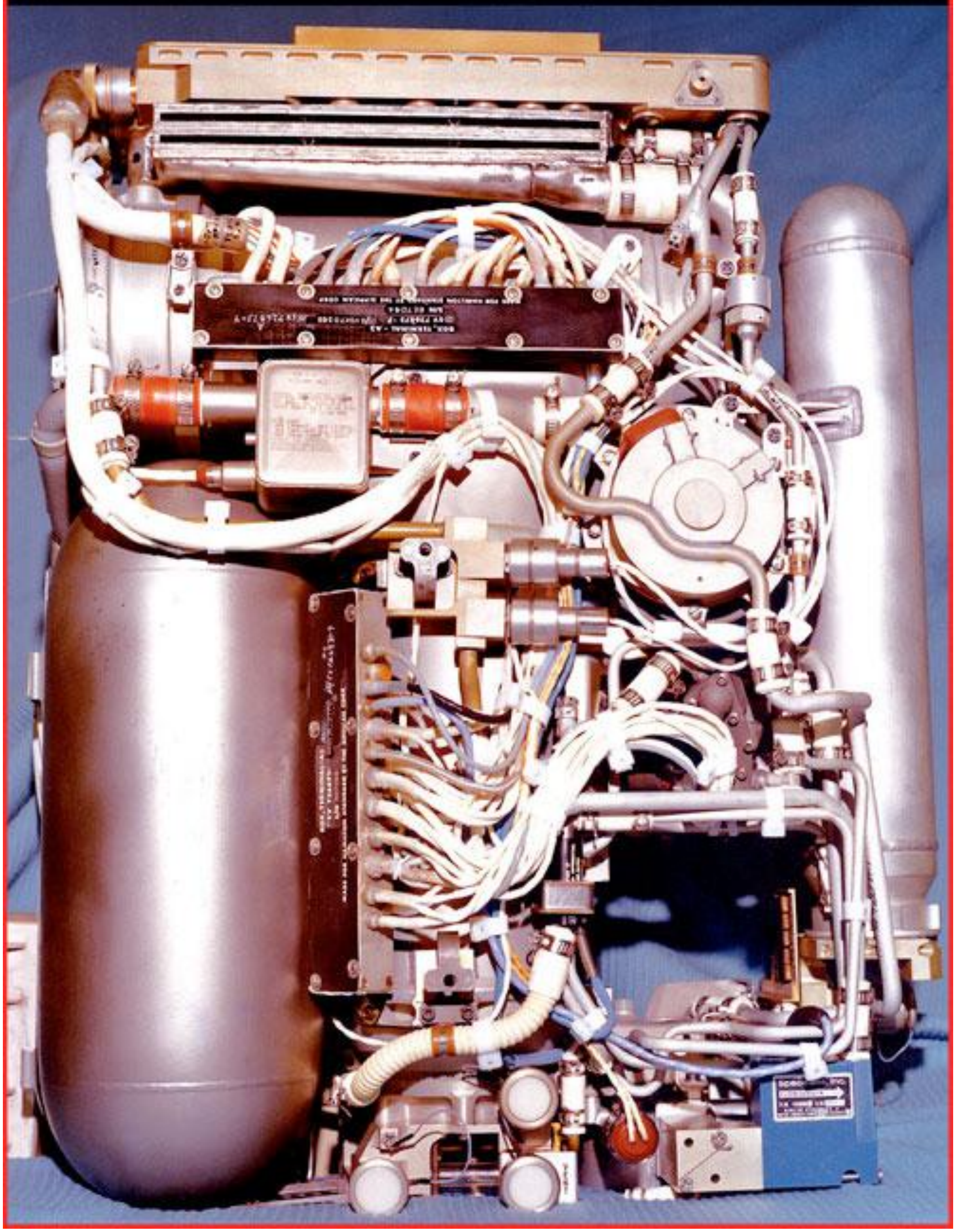
HOW THEY DIFFERED FROM FLIGHT HARDWARE AND PROBLEMS WE ENCOUNTERED AND SOLVED DURING EVA CREW TRAINING

I will discuss my experiences (as PLSS/OPS EVA Crew Training Mission Manager) pertaining to the equipment used, the problems associated with the equipment used and the changes made to solve problems so that we never missed a planned crew training exercise as a result of equipment and associated problems.

MY STORY WILL BE RELEVANT FOR HISTORIANS THAT LOOK BACK AND WANT TO KNOW HOW APOLLO MISSION EVA TRAINING WAS ACCOMPLISHED AS THERE IS VERY LITTLE DOCUMENTED INFORMATION SINCE I WAS TOTALLY RESPONSIBLE FOR THE PLSS/OPS TRAINING HARDWARE USED.

For those of you who assumed that training PLSS/OPSs were functionally equivalent to flight hardware and therefore could be used for earth training, you were wrong, as the flight PLSS ventilation cooling and LCG water cooling capability was based on the process of sublimation (a solid [ice] converted directly to a gas without passing through the liquid phase) that required the vacuum of space.

1 FLIGHT PLSS
(REAR VIEW WITHOUT COVER)



2 **TRAINING PLSS CRYOPACK**

(REAR VIEW WITHOUT COVER)

My responsibilities as Apollo PLSS/OPS KSC EVA Crew Training Mission Manager began with a memo from MSC Crew Systems Division stating that the remaining Apollo 11 and all future mission EVA crew training exercises would be conducted at KSC and all EMU training hardware (suits, PLSS/OPSs, and supporting hardware) would be shipped to KSC in time for a June 6, 1969 KSC training exercise.

PLSS/OPS crew training hardware had already been designed and fabricated and was being used at MSC for Apollo 11 and preliminary Apollo 12 EVA Training. The PLSS/OPS training hardware that we received from MSC to support KSC EVA training was, contrary to popular belief, totally functionally different than the flight PLSS/OPS whereas the training suits were flight configured and downgraded to training status. Let me repeat and this is very important, *The PLSS/OPS training hardware was totally functionally different from PLSS/OPS flight configured hardware.*

I will discuss my experiences and the decisions I had to make (as Apollo PLSS/OPS KSC EVA Crew Training Mission Manager) as a result of maintaining and managing PLSS/OPS EMU training hardware that did not perform as expected. It is a story that was never documented and in the interest of preserving and documenting a very important aspect of the "Apollo Story" for future historians I feel it is my obligation to document my experiences and the decisions I had to make.

Before I became involved with the PLSS/OPS training units, my work at KSC was with the Flight PLSS/OPS hardware. Because of my intimate knowledge of the flight hardware and my extreme enthusiasm about my work (my dream job), my request to be assigned PLSS/OPS Crew Training Mission Manager was granted (one of the many highlights of my Apollo experience).

I realized that I now had to familiarize myself with a totally new system both from a functional and procedural standpoint and concurrently continue my responsibilities as a KSC HSD engineer. Knowing the frantic pace at which Apollo schedules were moving forward I anticipated that my upcoming new responsibilities were going to be very challenging.

As I previously mentioned, the training PLSS Cryopack and OPS were totally functionally different from the flight configured PLSS/OPS. The flight PLSS/OPS was designed and built to function on the moon, not on earth. All components were, of course, designed with that in mind. The space suit ventilation cooling and body cooling (using the Liquid Cooling Garment, LCG) were accomplished through the process of sublimation, a process that only works in the vacuum of space using the PLSS sublimator that allowed ice to change from its solid state to a gas skipping the liquid phase. All other components were also specifically designed and optimized to function on the moon.

The PLSS was a fully autonomous system when used for its intended purpose on the moon. The PLSS controlled suit pressure, provided up to eight (8) hours of breathable oxygen, removed exhaled carbon dioxide, removed particulates and odors, provided body and ventilation cooling, controlled humidity and provided voice and telemetry communications.

Not only was the PLSS non earth function issue a reason for designing an earth training PLSS/OPS but also the weight of the flight PLSS/OPS would have been an issue as the flight PLSS/OPS weighed 125lbs (PLSS - 84lbs, OPS - 41lbs). With the suit at 60 lbs, a total of 180 lbs would have been a serious issue for the crew magnified even more on the simulated lunar surface outside the crew training building in the heat of the spring, summer and fall Florida sun.

The weight issue was not completely resolved since the final weight of the Cryopack, OPS and suit was 130lbs (Cryopack - 60lbs, OPS - 10.5lbs, Suit - 60lbs). The weight difference of 49.5lbs however was offset by the lack of Cryopack LCG water cooling capability until the beginning of Apollo 16 crew training when I was given authority to fabricate a "make shift" cooling device that I and one of my crew training techs designed.

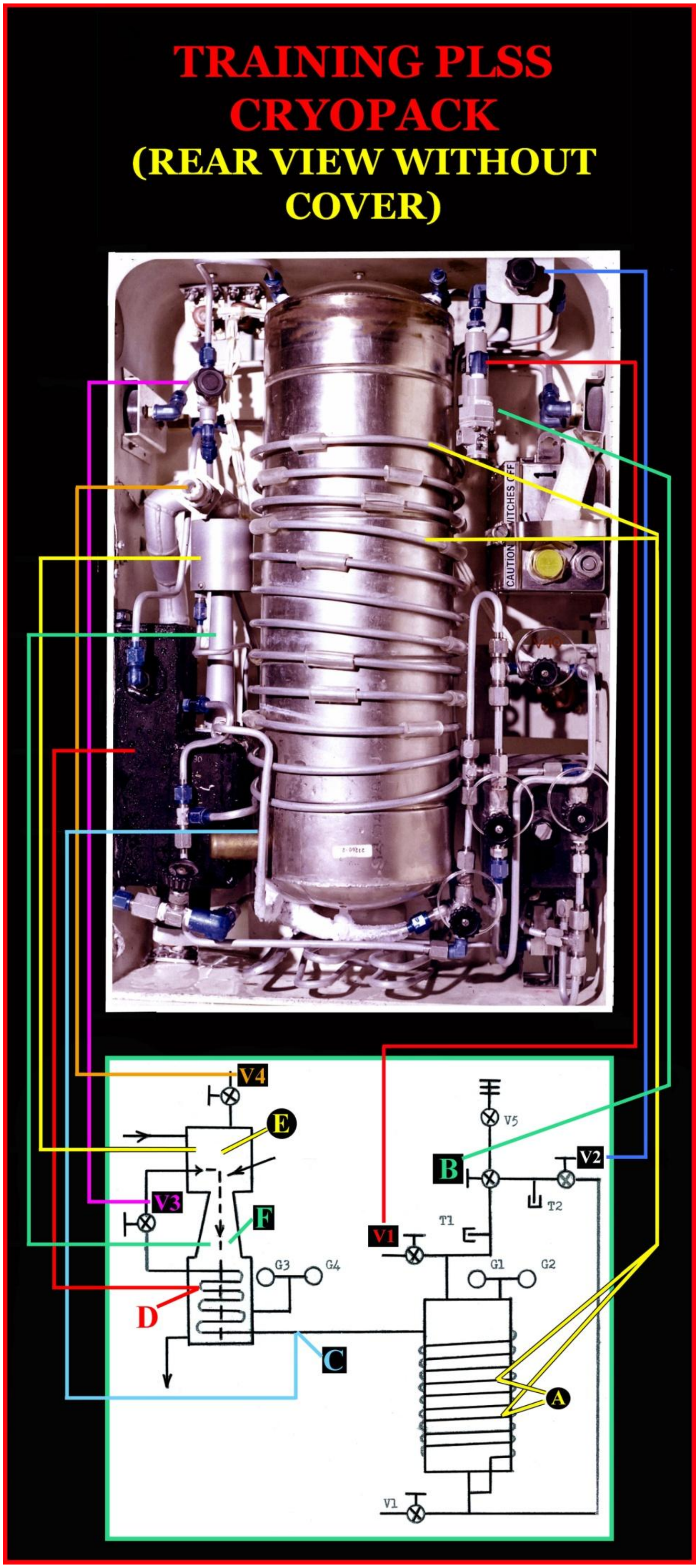
Using the flight PLSS carbon dioxide and odor removal capability would have also been unfeasible as the PLSS Lithium Hydroxide Cartridge was a one time use component and it would have been cost prohibitive to provide new cartridges for every crew training exercise.

My impression when I first compared the flight PLSS (Photo 1) to the training PLSS Cryopack (Photo 2) was one of questionable belief or perhaps disbelief. What I saw when looking at the Cryopack was hardware that might have been built in someone's garage! In retrospect, comparing the Cryopack to the flight PLSS that I had lived with day in and day out and labeling it as "garage built" may have been a little too harsh. However, my initial observation may not have been too far off!

I've established that the PLSS/OPS training hardware was totally functionally different from PLSS/OPS flight hardware. I also provided rationale why the flight PLSS/OPS could not be used as a 1-G training option.

When the PLSS cryopacks were received at KSC from MSC on June 4, 1969, they were accompanied by an MSC HSD technician whose responsibility was to provide myself and two HSD KSC techs the necessary information required to understand the "function" and "procedural use" of the cryopacks in time for a June 6, 1969 EVA training exercise at KSC.

CRYOPACK FUNCTIONAL OPERATION



The cryopack provides pressurization and ventilation to the astronaut during Lunar Surface EVA crew training exercises. Liquid Air is utilized to accomplish the required objectives. Liquid Air is air that has been cooled to less than -221.26°F so that it condenses into a pale blue liquid. To protect the Liquid Air from reverting back to its gaseous state before it is functionally utilized (liquid air can absorb heat rapidly and revert back to its gaseous state), it is stored in a vacuum insulated container. In the case of the Cryopack, the insulated container is cylindrical as seen in the above photo.

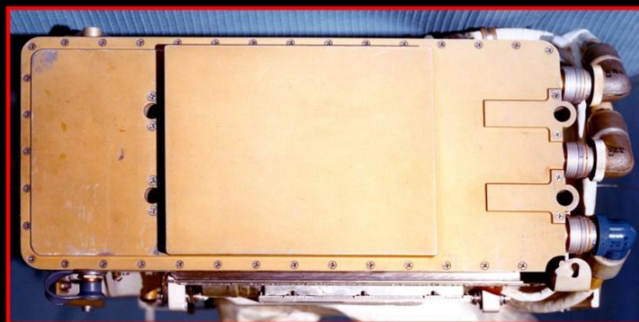
The Cryopack operates as follows (refer to above photo): After the pack is filled (with Liquid Air), Vent Valve (V-1) is closed and Pressure Buildup Valve (V-2) is opened. This allows the liquid air to enter the Build Up Coil (A), vaporize and pressurize the Dewar to 140±3 psig at which time the Pressure Regulation Valve (B) closes and stops flow into the Build Up Coil (A). The Pressure Regulation Valve (B) then modulates between open and closed to maintain system pressure.

Opening Supply Shutoff Valve (V-3) allows system pressure in top of the Dewar to force liquid air from the bottom of the Dewar into Supply Line (C). The Liquid Air then passes through Heat Exchange Coils (D) to ensure complete vaporization before entering and exiting an Ejector (E) as a high velocity stream of gas. The ejected gas directed into Venturi (F) induces ventilation flow to the Suit Inlet Hose. A sufficient amount of gas is "dumped" out of the Suit Purge Valve (located in the suit exhaust line) to maintain CO_2 levels below 7.6 mm Hg. A Suit Pressure Valve (V-4) is used to pressurize the suit to 3.75 psi. System Pressure and Suit Pressure are monitored on duplicate gauges on both sides of the Cryopack. Cooling from the ventilation gas provided heat removal up to 1200 btu/hour. The Cryopack was designed to operate for 1.5 hours.

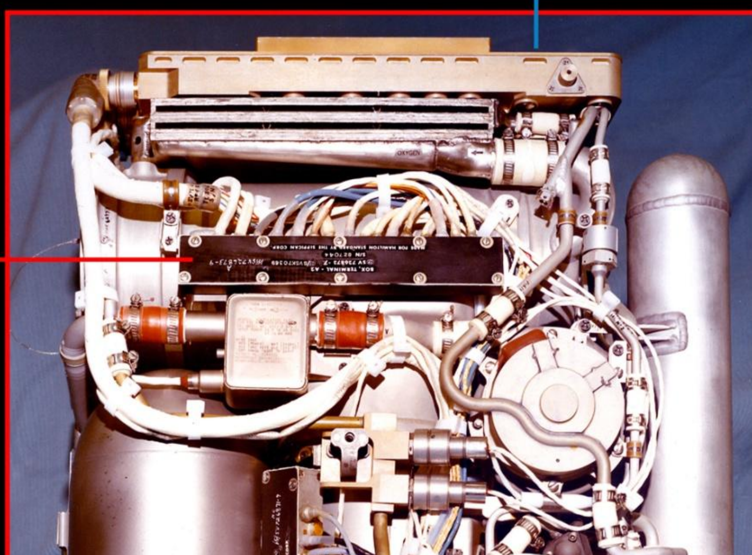
PLSS COMMUNICATIONS SYSTEM

1

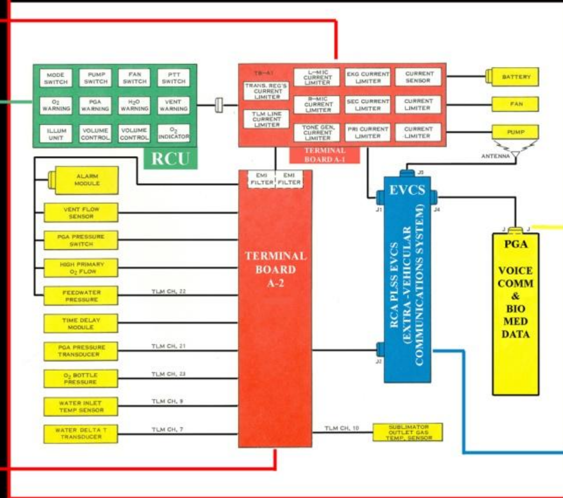
EVCS



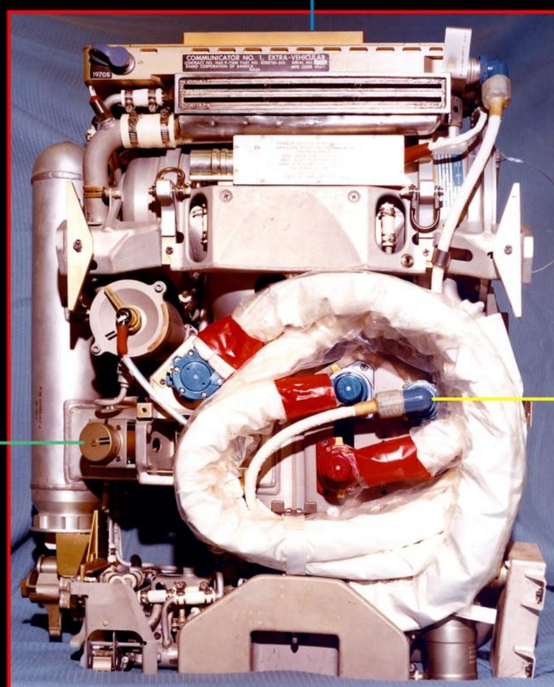
PLSS REAR



FLIGHT PLSS COMMUNICATIONS SYSTEM BLOCK DIAGRAM



PLSS FRONT



REMOTE CONTROL UNIT

1

As I previously discussed and emphasized, the training PLSS Cryopack was totally functionally different from the flight configured PLSS. I covered differences between the flight PLSS and Cryopack Suit Ventilation, Suit Pressurization and Suit Cooling capabilities. Differences between the flight PLSS/OPS and training PLSS Cryopack Communications System have not yet been addressed.

To that end, I will discuss PLSS and Cryopack Communications System differences. First let's take a look at the flight PLSS Communications System referred to as the Extra Vehicular Communications System (EVCS). In Figure 1 above, I "attempted" to relate EVCS Block Diagram components to corresponding components in front and rear photos of the PLSS and the PLSS Remote Control Unit (RCU).

The EVCS, manufactured by RCA, accomplished three major communications objectives as follows:

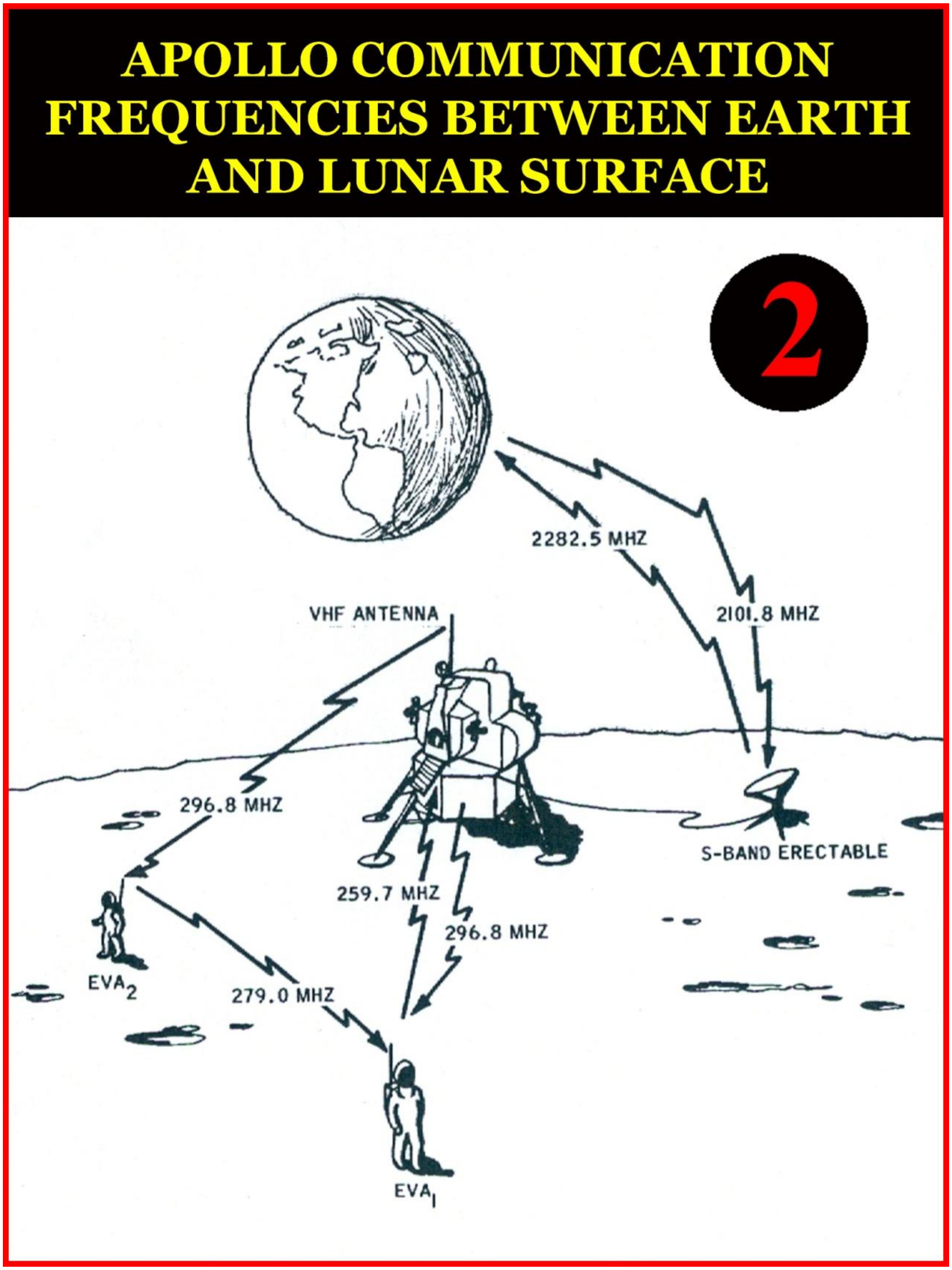
- Provide primary and backup Dual Voice Transmission and Reception between earth and moon.
- Provide Telemetry Transmission of Physiological (Bio-Medical) data to earth.
- Provide Telemetry Transmission of PLSS Performance (Function) data to earth.

As the bullet points indicate above, the EVCS provided primary and backup dual voice transmission and reception, telemetry transmission of astronaut physiological and PLSS performance data. The EVCS also regulated voltage and electrical current of PLSS operational sensors (transducers). Operation of the communication system in the dual mode provided crew members with uninterrupted duplex voice communications with one another, with the LM and, via the LM through a crew erected S-Band antenna to Mission Control. Telemetry information was transmitted without interrupting or interfering with voice communications.

Nine telemetry channels transmitted to the LM carried PLSS and suit operational data. A tenth TM channel transmitted crewman electrocardiogram (ECG) data. Indicators mounted on the remote control unit (RCU photo in Figure 1) provided the astronaut with a visual warning of high oxygen usage rate, low suit pressure, low ventilation flow, low water pressure and high CO2 levels (Note the block diagram in Figure 1 does not include CO2 sensor monitoring as CO2 level monitoring was added later in the program) . When an abnormal (out of specification) condition existed, an audible tone sounded in the astronaut communications carrier (Snoopy headset). The audible tone alerted the crewmember to look down at his Remote Control Unit (RCU) to find the specific abnormal condition(s) defined by specific visual notification that appeared in RCU indicator windows, identifying the problem so that the astronaut was able to take corrective action.

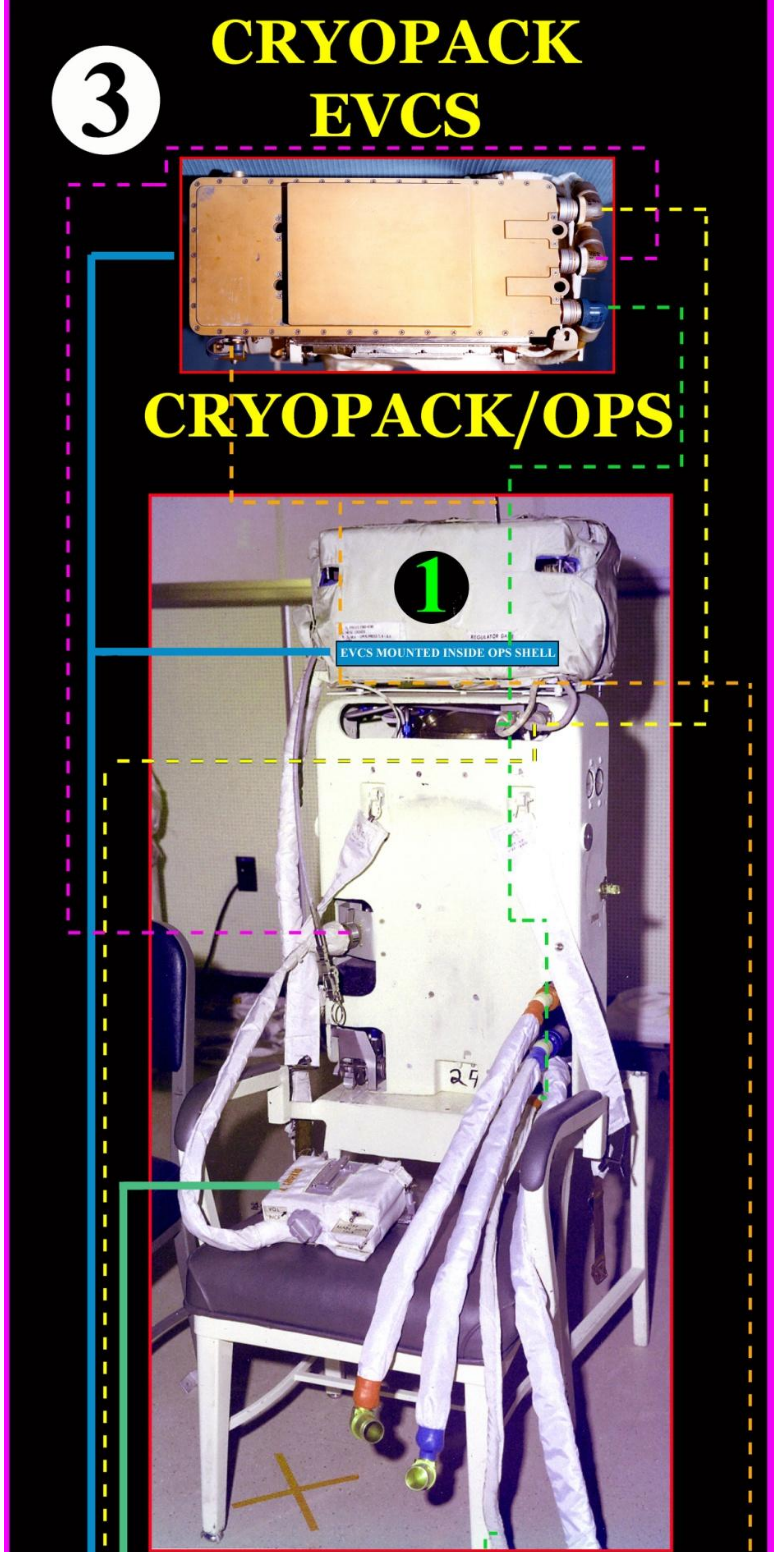
Voice and telemetry communications was sent and received on three frequencies between the crewman and the LM.The astronauts communicated with each other via 279.0 MHZ. Voice communications from LM to the crew utilized 296.8 MHZ. Voice and data from the crew to the LM utilized 259.7 MHZ, however, voice and data from EVCS 2 (LMP) had to be transmitted to EVCS 1 (CDR) and then voice and TM from both crewman were transmitted to the LM through EVCS 1. Note that other optional communications modes were available (utilizing the RCU mode selector switch) if anomalies occurred.

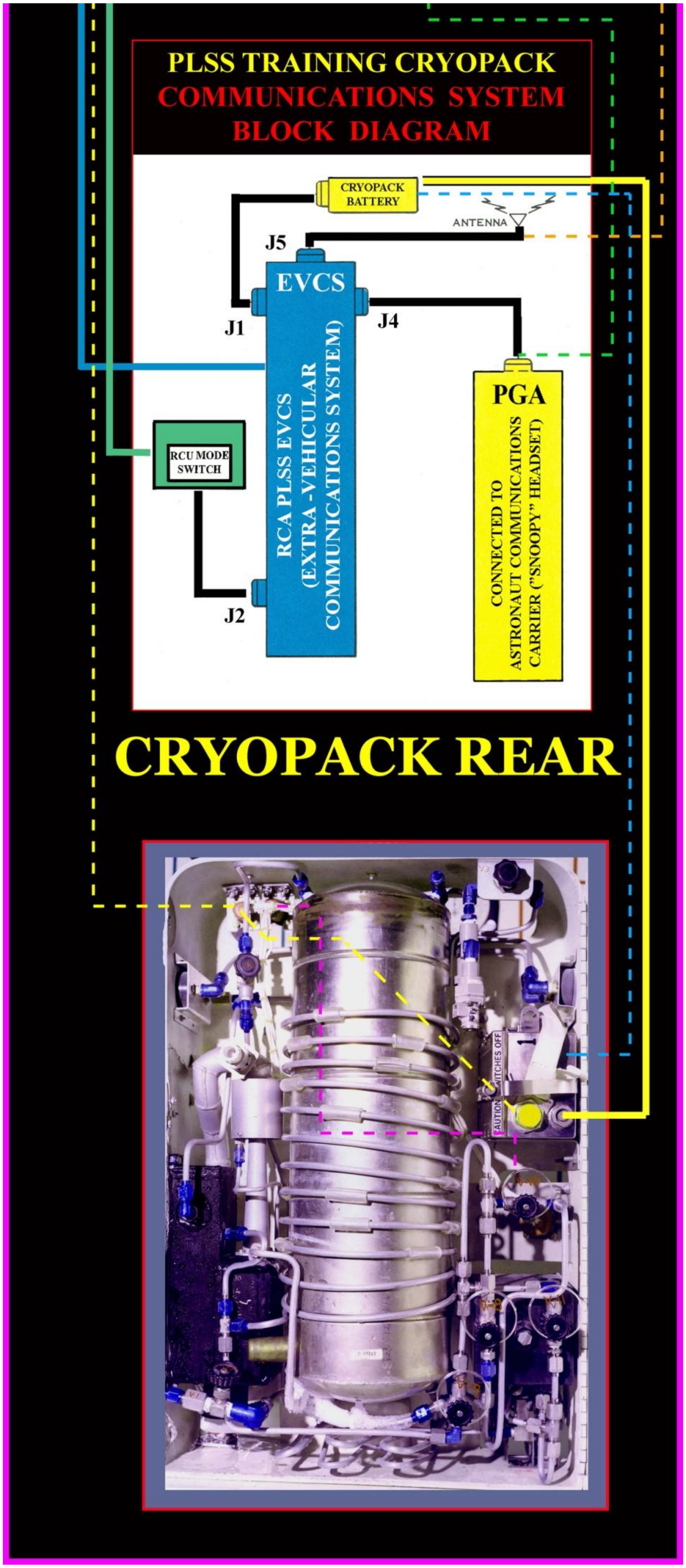
Voice and TM data was transmitted from the LM to earth via the aforementioned S-Band antenna erected by the astronauts using frequency 2282.5 MHZ. Voice from earth to the S-Band antenna was relayed via 2101.8 MHZ. The below Figure 2 may help decipher my explanation.



It is obvious that the EVCS was a technological marvel for its time. I stated at the beginning of this section that I will compare the flight PLSS EVCS to the Cryopack EVCS. What if I told you that the Cryopack EVCS hardware was identical to the PLSS EVCS! Yes, however, the capabilities of the EVCS were only partially utilized when used with the Cryopack for EMU training.

CRYOPACK EVCS COMMUNICATIONS SYSTEM




PLSS TRAINING CRYOPACK
COMMUNICATIONS SYSTEM
BLOCK DIAGRAM
CRYOPACK
BATTERY
ANTENNA
J5
EVCS
J1
J4
RCA PLSS EVCS
(EXTRA-VEHICULAR
COMMUNICATIONS SYSTEM)
PGA
CONNECTED TO
ASTRONAUT COMMUNICATIONS
CARRIER ("SNOOPY" HEADSET)
RCU MODE
SWITCH
J2
CRYOPACK REAR

I previously documented the operational functions of the flight PLSS Communications System (EVCS). As a reminder, the PLSS EVCS was utilized to provide voice communications and telemetry data for both astronaut bio-medical and PLSS operational data.

I also mentioned that the Cryopack EVCS hardware was identical to the PLSS EVCS! However, the capabilities of the EVCS were only partially utilized when used with the Cryopack for EVA training. Specifically, communications using the Cryopack EVCS was used for voice communications only. TM data transmission from the training PLSS Cryopack was not needed as there were no transducers in the Cryopack to monitor and send performance data and it was deemed not necessary to monitor astronaut ECG data. The thinking was that the close contact between crew members, techs and myself would allow us to visually recognize astronaut life threatening situations.

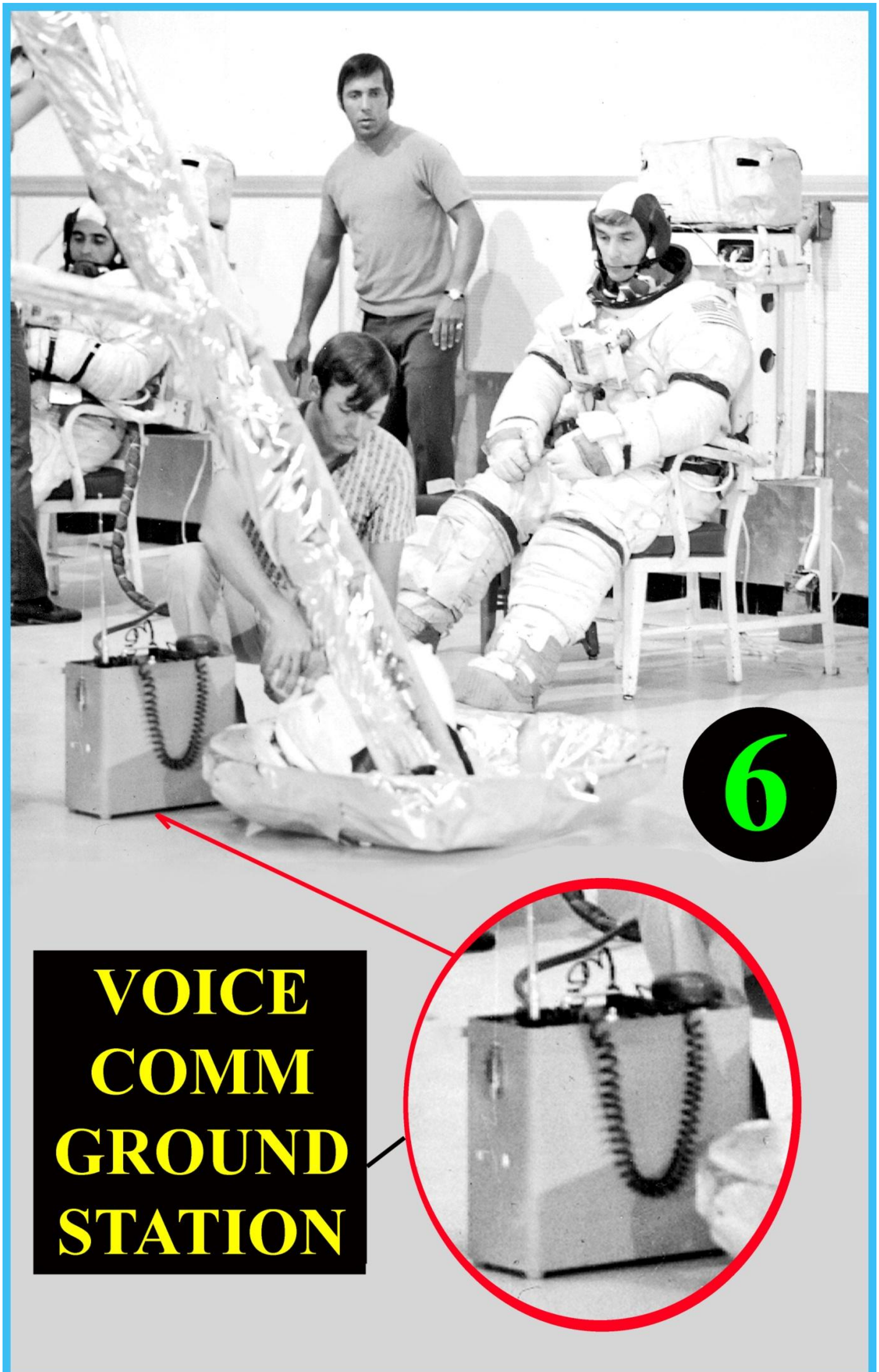
The training EVCS was mounted inside an OPS shell (Above Figure 3, #1) as there was no need for a working emergency oxygen system.

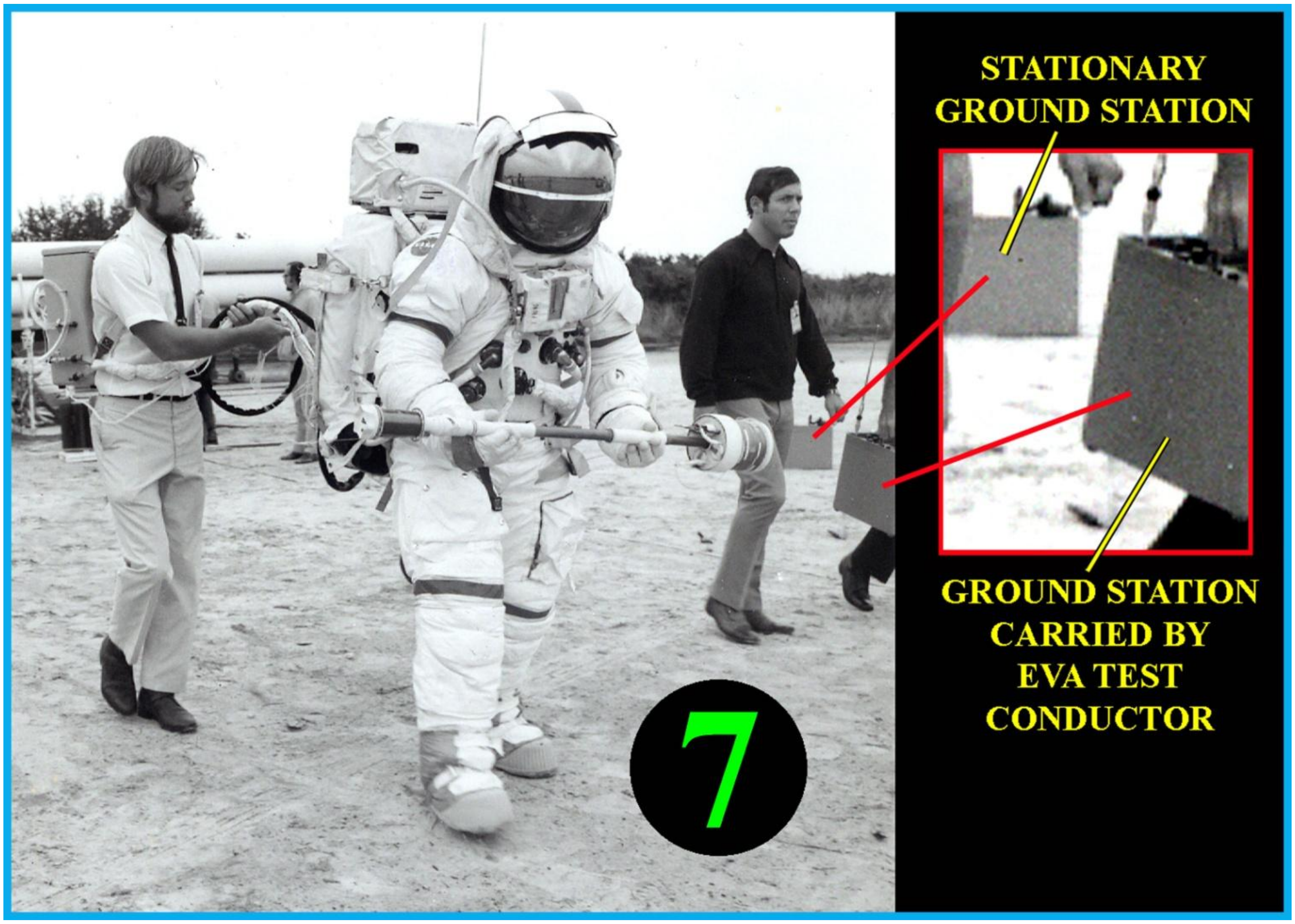
The above Figure 3 Cryopack communications Block Diagram shows EVCS connector "J4" connected to the PGA electrical umbilical connector in turn connected internally to the astronaut communications headset. EVCS "J5" connector is connected to the EVCS antenna mounted on top of the (OPS). EVCS "J1" connector was connected to a battery inside the Cryopack providing the EVCS with its power source. EVCS "J2" connector was connected to the PLSS RCU. Since there was no telemetry data, the only function of the RCU was to turn on EVCS voice communications by pushing the RCU "Push To Talk Switch" from "OFF" to its "MAIN" position and then rotating the RCU Mode Selector Switch from its off position "0" to its primary on position "AR".

Referring to Figure 3, I tried to identify as many cables, components and connectors (using dotted lines) related to Cryopack voice communications as possible within constraints of available photos.

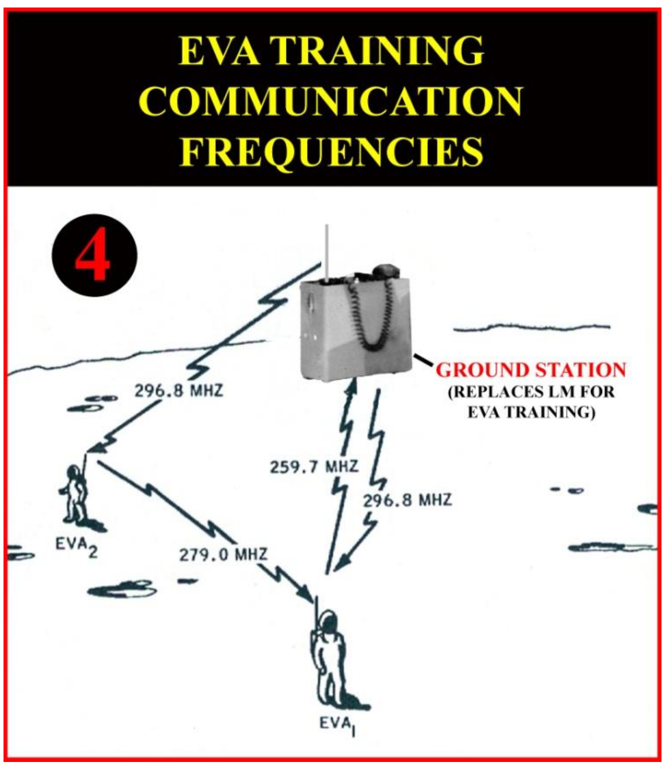
Continuing with the functional communications aspect of the EVA training Cryopack, the LM (not literally) was "replaced" by a Ground Station capable of sending and receiving voice communications (Photos 5, 6 and7). The Ground station had a speaker and a microphone attached to an expandable cord. Speaker voice content could easily be heard within a 20 to 30 foot radius of the station. The Ground station was also portable so it could be carried from one training site to another (see photos 5, 6 and 7 below). For every crew training EVA exercise there were two ground stations, one used by the test conductor and the other used by techs and myself.


VOICE
COMM
GROUND
STATION
5


6
VOICE
COMM
GROUND
STATION



Completing the Cryopack communications description, it should be pointed out that Communication frequencies were identical to the frequencies used between the crew and the LM on the Lunar surface, i.e. 296.8 MHZ,279.0 MHZ and 259.7 MHZ (Figure 4). A day before all scheduled EVA training exercises I had to call for frequency clearance to use the three required frequencies.



MY CONCERNS AND EXPERIENCES WITH THE CRYOPACKS

Now that I've described the differences between the flight PLSS and the astronaut training cryopacks, let's discuss my concerns and experiences with the cryopacks used by the astronauts during EVA mission training exercises.

When my two HSD techs and myself were provided the information necessary to understand the function and procedural use of the cryopack, it was time to take over the KSC PLSS/OPS EVA crew training operations. In retrospect, I'm not sure if I recognized the significance of the important responsibility that I was given as PLSS/OPS EVA crew training mission(s) manager.

As we all know, meeting the deadline set by President Kennedy before the end of the decade, Dec. 31, 1969 to land a man on the moon and bring him back safely, required meeting schedules that seemed unrealistic to many and achievable to some, i.e. schedule deadlines that, at least for me, did not give me time to contemplate the reality of my responsibility to provide reliable hardware (PLSS/OPS) for each and every EVA training exercise for Apollo 11 through Apollo 17, hardware, that would provide the "life sustaining" breathable air, carbon dioxide removal, communications and cooling.

I had my challenges, and very real concerns about hardware reliability and future potential problems. My very first concern was that the cryopacks did not come with a "paperwork" trail, meaning that there were absolutely no written procedures to inspect and test the cryopack. Yes, that's exactly what I said!

When I asked for inspection and testing procedures, I was told that they do not exist! I was, as you can well imagine, very concerned, to say the least. Every other "life support" (life support being the operative word) hardware system whether used for flight or training required procedures for periodic testing and inspection, procedures for inspecting hose lines, line fittings, hose nozzles for cracks, nicks, cuts, etc. There were also no requirements for functional testing to confirm that all system and component specifications were met, neither informally or formally with a KSC approved and signed document. The cryopacks did not even have a data package that would have included the inspection, testing, charging, cleaning, malfunction and repair history. Being so involved with testing flight PLSS/OPSs, all I could do was "scratch my head" in disbelief!

An example of life support equipment that included the normal requirements for documentation, as I discussed, is the astronaut purge and transfer ventilator that was maintained by the Bendix Corporation at KSC. The ventilator was a handheld unit with a suit inlet and outlet hose connected to the suited astronaut that was used to pre-oxygenate (in a 100% oxygen environment) the astronaut prior to decompression for transfer from the suit room to either chamber tests or transfer to the launch pad via a "transfer van."

It is more than interesting to note that the ventilator functionally operated identically to the cryopack. The procedures for testing and inspecting the ventilator were documented in an approved and signed KSC document. That being said, there were serious ramifications with the absence of cryopack procedural testing and inspection requirements.

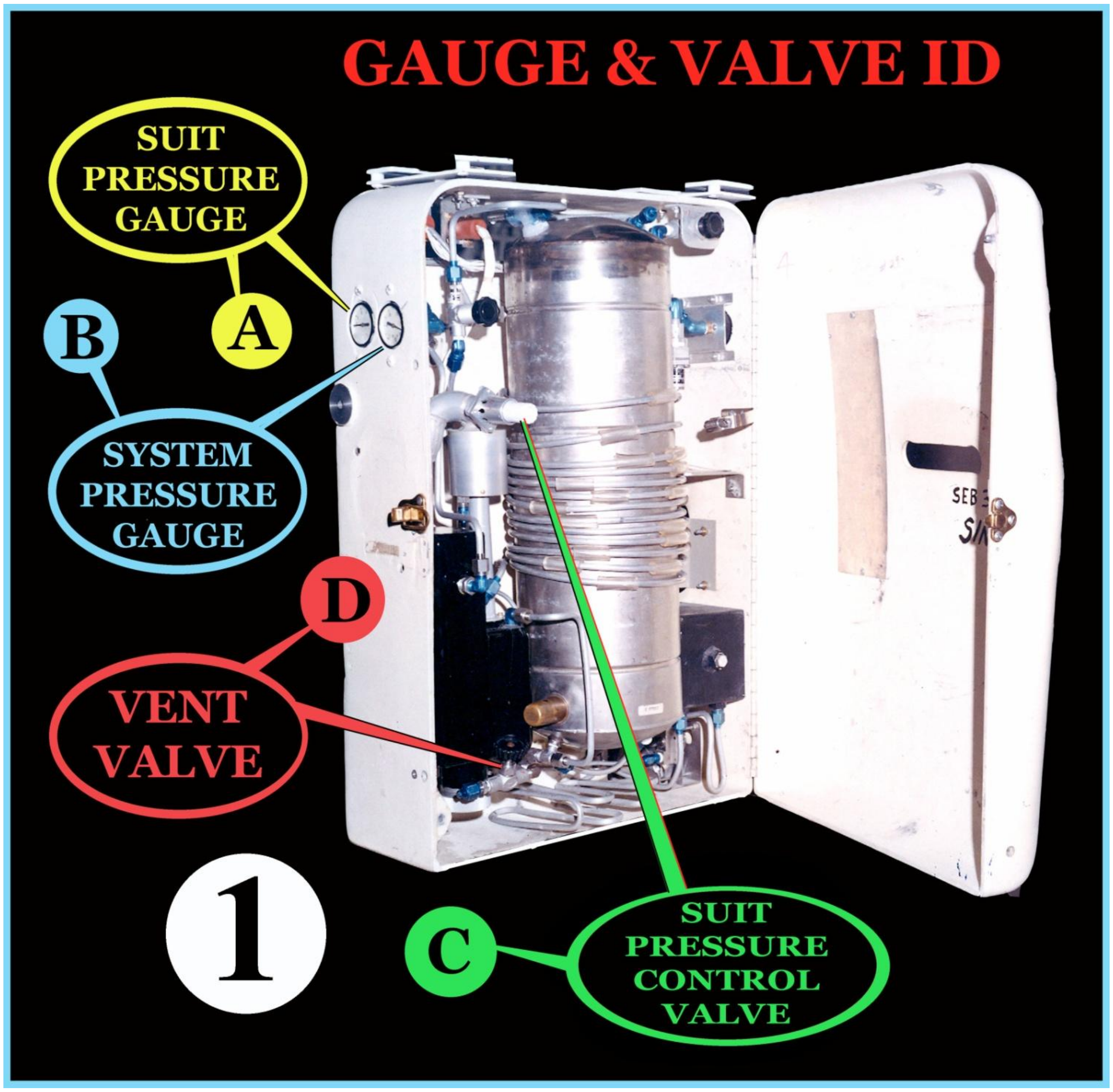
I had very real concerns about cryopack hardware reliability and future potential problems. Those concerns were, in my mind, justified as the cryopacks did not come with the aforementioned "paperwork" trail, meaning that there were absolutely no written procedures to inspect and test the cryopack. The overriding concern for me was the "SAFETY" of the crew during EVA training exercises. Many times, literally, my concerns prevented me from getting a good night's sleep.

Not only were the flight PLSSs tested and inspected many times over following very detailed and approved signed procedures, they also provided telemetry to monitor bio-medical and PLSS performance data and included a built in out of spec alert system, i.e. audio alarms and remote control unit visual alerts that prompted the crew member to implement practiced emergency procedures.

Knowing that potential reliability problems existed along with the inability to monitor astronaut EKG and cryopack real time functional performance, I tried my best to implement astronaut EVA "work around" monitoring procedures that first and foremost addressed the "SAFETY" of the crew.

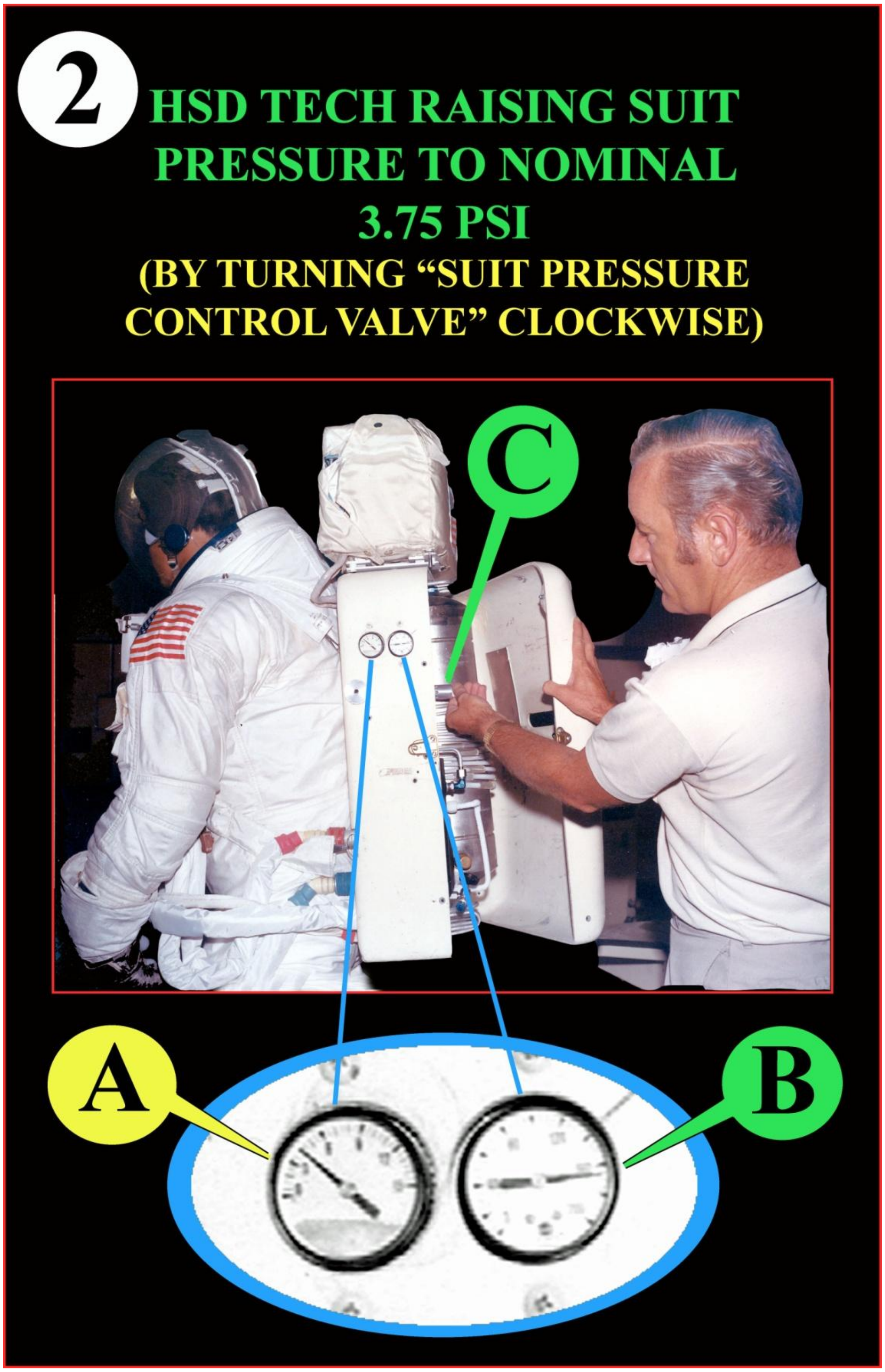
Our cryopack training briefing was based on monitoring procedures used at MSC. As we discovered, there were no formal crew "SAFETY" procedures. As I became more familiar with the PLSS training cryopacks after supporting several crew training exercises, I was able to generate astronaut safety procedures based on "what I had to work with!" I subsequently incorporated my written procedures in a document appropriately titled "Procedures For Testing The Astronaut Training Cryogenic Life Support Back Pack," KSC Procedure NO: CTE-H-3001/KL-9650. This, in fact, was the inspection and testing procedural document that did not exist, a document that should have been written before the cryopacks were approved for astronaut life support.

Before I discuss the astronaut crew training EVA "SAFETY" procedures I wrote, it is necessary to define specific cryopack components that are identified in the subject procedures. In cryopack photo #1 (below), I've identified Suit Pressure Gauge "A," System Pressure Gauge "B," Suit Pressure Control Knob "C" and Vent Valve "D."



In photo #2, my cryopack tech is turning the suit pressure control valve knob "C" clockwise to increase suit pressure to 3.75 psi. An enlargement of suit pressure gauge "A" shows that it does in fact read 3.75 psi. The enlargement is a little "blurry." I'm sorry for that but it was the best I could do. System pressure gauge "B" shown enlarged, reflects a system pressure of 160 psi (again, a little blurry) which is the nominal cryopack system pressure reading after a full Liquid Air charge.

In case of either a suit pressure emergency (low or high) or a system pressure emergency (low or high) the hinged cryopack door permitted easy access to both the suit pressure control valve "C" and vent valve "D." These were the valves that were referred to be used in my safety procedures to follow.



Following are the safety procedures that I wrote and implemented:

EVA CRYOPACK/SUIT TRAINING SAFETY PROCEDURES

SYMPTOM	ACTION
1) SYSTEM PRESSURE GAUGE FALLS BELOW 160 PSI	1) NOTIFY TEST CONDUCTOR WHO WILL IN TURN NOTIFY CREWMAN. CREWMAN WILL BE LED TO DOFFING AREA WITHIN 15 MINUTES OF INITIAL SYSTEM PRESSUE GAUGE DECREASE. CRYOPACK TECH WILL DECREASE SYSTEM PRESSURE TO 0 PSI USING CRYOPACK SUIT PRESSURE VALVE. CREWMAN WILL BE SEATED. SUIT TECH WILL REMOVE HELMET.
2) SYSTEM PRESSURE GAUGE BEGINS TO INCREASE	2) CRYOPACK TECH OPEN CRYOPACK DOOR AND OPEN CRYOPACK VENT VALVE TO FULL DECREASE. PERFORM ACTION 1.
3) SUIT PRESSURE GAUGE INCREASES	3) OPEN CRYOPACK DOOR AND DECREASE SUIT PRESSURE TO 0 PSI. PERFORM ACTION 1
4) CREWMAN VISOR FOGGING	4) CRYOPACK TECH DE-PRESSURIZE CREWMAN SUIT USING SUIT PRESSURE VALVE. SUIT TECH REMOVE HELMET WHILE CREWMAN IS STANDING. IN THIS SCENARIO THERE IS NO TIME TO WALK THE CREWMAN TO DOFFING AREA.
5) CREWMAN COMPLAINS OF EXTREME HEAT OR LOW FLOW	5) SAME AS ACTION 4
6) RAPID DECREASE IN SYSTEM PRESSURE	6) SUIT TECH PULL SUIT PURGE VALVE AND REMOVE HELMET.

Photo #3 reflects the ideal astronaut safety monitoring "situation", i.e. the cryopack suit pressure and system pressure gauges are visible (not blocked as I will explain later) and astronaut helmets are visible (not blocked by UV visors). These conditions are necessary to implement the symptom/action procedures (above).

In photo #4, astronaut UV visors are engaged covering the helmet preventing awareness of Symptom #4 (visor fogging) and preventing Action #4 implementation.

In photo #5, Apollo 13 LMP Haise's UV visor is not completely covering his helmet. With the UV visor partially up, there is room to "peek" in to see if his helmet was fogging, i.e. Symptom #4 in Safety Procedures.

The photo #6 scenario represented a very dangerous "SAFETY" situation. As you can see, not only are the Apollo 17 astronauts Cernan and Schmitt's UV visors "A" down, but the suit pressure and system pressure gauges are covered by a tool holder "B" on one side and a sample bag "C" on the other side (both sides of the cryopack had duplicate gauges).

Communication capability with the astronauts via the portable ground stations was the last "lifeline" remaining to monitor the physiological condition of the crew. We were very cognizant of this situation and I met with each EVA training mission test conductor before the first training exercise for that mission. I discussed my "SAFETY" procedures and in the case of the photo #6 scenario (visors down, gauges blocked), I suggested and they all agreed they would ask the crew if they were okay about every ten (10) minutes. It was agreed that I would keep track of the time and would signal the test conductor by pointing to the crew when I knew I had the attention of the test conductor.

With the crew on the rover (as in photo #7), an additional challenge was walking and sometimes running to keep up with the rover to monitor gauges (if not covered) and helmet fogging (if not covered). Additionally, while "chasing" the rover we carried the "not so light" ground station communications unit "A" (photo #7).

In photo #7, the rover is not moving and it appears that I'm trying to catch my breath after running and carrying the ground station.

PREPARATION FOR AN EVA TRAINING EXERCISE AND AN EXAMPLE OF PROBLEMS THAT WERE EXPERIENCED

I prepared for a scheduled crew training EVA exercise at Kennedy Space Center as follows:

- At 9:00 a.m., one day before the scheduled exercise I called the KSC Crew Systems Division (CSD) EVA Test Conductor to confirm that the exercise was a "go."
- If the test was on, I called the Bendix Corporation located at KSC Hanger S to schedule four cryopacks to be charged (filled) with liquid air the day before the scheduled exercise.
- The four cryopacks were loaded into the HSD government issued Dodge van and were transported to Bendix.
- The charged cryopacks were picked up from Bendix at 8 a.m. the next day (morning of the scheduled exercise) and brought back to the HSD building. They remained in the van until it was time to drive to the KSC Crew Training Building in time for the scheduled exercise.

The crew donned their suits with help of ILC (suit) and HSD (cryopack) techs. After checking voice communications, cryopack pressure was increased to a nominal 160 psi. Suit pressure was then set at 3.7 psi.

EVA training exercises were scheduled to last from one to 2.5 hours. The designed nominal cryopack operational time was 1.5 hrs. With two available charged cryopacks for each crewman, a nominal combined cryopack operational time of three hours was possible with a half hour to spare. This was the criteria I used for setting up and managing the KSC EVA training program.

As we've all experienced, things don't always work as designed and planned. The cryopacks were no exception. One of my first negative experiences occurred during an indoor EVA exercise with Apollo 12 LMP Al Bean.

About 25 minutes after the beginning of the "run" (exercise) one of my two HSD techs came over to me and said that astronaut Bean's cryopack pressure was slowly decreasing from the nominal 160 psi operating pressure.

I notified the test conductor. As per the "EVA Cryopack/Suit Training Safety Procedures" that I authored (outlined in a previous post), the crewman had no more than 15 minutes of breathable air remaining. The test conductor asked if he could have about five minutes to complete the deployment of the Solar Wind Spectrometer (seen in the below photo). I said yes to the test conductor and when the deployment task was completed, my HSD tech (per the Symptom/Action Safety Procedures) decreased the system pressure to 0 psi. Astronaut Bean was led to his suit donning/doffing chair, suit pressure was reduced to 0 psi and Al's helmet was removed.

For those of you that have a sense of humor, I thought it would be amusing to compare the Solar Wind Experiment to R2D2 (below photo).

To continue the exercise, the second cryopack was secured to crewman Bean and the exercise continued as if "nothing happened!" Picture the following scenario. Knowing that the first cryopack operated for 25 minutes, knowing that the replacement second cryopack theoretically had 1.5 hours of normal operation and knowing the total test time (test conductor's estimate) was two hours and 15 minutes we had a problem.

Even if the replacement cryopack lasted 1.5 hours (of course, after what happened with the first unit, I had my doubts), we were short 20 minutes. I tried not to panic. I calmly went to the wall phone (below photo) and called Bendix saying we had an "emergency" situation that required charging a cryopack. My Bendix contact was very cooperative and asked what he could do.

I said I was sending my tech Ray with the cryopack to him to be immediately charged so it could be returned to the Crew Training Building within one hour. I left myself a 15 minute buffer as the exercise had already run 15 minutes before my tech left the building and headed for the Bendix facility.

I was mentally in "panic mode" but I tried not to show it. I prayed that the replacement cryopack would last for the expected 1.5 hours and that my tech would return within the planned hour. I called Bendix twice for a status update. My primary concern was for HSD to not be responsible for shutting down a crew training exercise before all objectives were completed.

About a minute before my remaining HSD tech (we always had two) notified me that the system pressure of the cryopack in use began to decrease, in walked my tech Ray carrying the recharged pack with very little time to spare. Bottom line, the exercise was successfully completed.

The fact that the run might have been cut short, was known only by three individuals, i.e. me and my two HSD techs! And that's the "rest of the story!"